AUTOTEST

PROGRAMMABLE

F.M./A.M. MODULATION METER

TYPE TF 2301A

INSTRUCTION MANUAL

MP MASTER

MA30926

mi

MARCONI INSTRUMENTS

INSTRUCTION MANUAL

FOR

PROGRAMMABLE F.M./A.M. MODULATION METER

TF 2301A

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Chapter 1 GENERAL INFORMATION

1.1 INTRODUCTION

TF 2301A is a Programmable F. M./A. M. Modulation Meter which, although primarily intended for use in automatic test systems, can be used as a manually operated instrument.

The instrument is principally designed for automatic measurements of f. m. deviation in selected ranges from 1.5 kHz to 500 kHz at modulation frequencies 30 Hz to 150 kHz and a. m. depths up to 95% at modulation frequencies 30 Hz to 15 kHz. However, it can be used within the limitations of the instrument, to measure a. m. on f. m. or f. m. on a. m. or inherent noise of the equipment on test.

Basically, the instrument is a low sensitivity superheterodyne receiver having very linear f. m. and a. m. demodulators.

The demodulated signal is amplified, then rectified, and the resulting d. c. is, for automatic measurements, passed to an output socket for connection to equipment in the test system or, for manual measurements, to a panel meter which is calibrated directly in kHz deviation for f. m. measurements, and per cent modulation depth for a. m. measurements.

For measurement of distortion or a more accurate indication of small f. m. deviations, an output is provided to enable connection of a sensitive external meter or other secondary equipment.

Generally, when the instrument is incorporated in an automatic system, the local oscillator signal is obtained from a programmable signal generator. Alternatively, for repeated measurements at a fixed frequency input, a crystal controlled oscillator can be used.

The instrument, which employs transistors and solid state elements, is designed for easy servicing and operates from a. c. supplies of 95 to 130 V or 190 to 260 V, 45 to 65 Hz and although usually supplied for rack mounting, a modification kit is available to enable the instrument to be used on a test bench.

1.2 MECHANICAL CHARACTERISTICS

Modulation Meter TF 2301A mainframe consists of front and rear panels which are supported by side structures which also hold the chassis and the power unit.

All manual controls are located on the front panel and inputs and outputs are conveyed through plugs and sockets located on the rear panel of the instrument which also carries the voltage selector switch and fuses.

1.2 continued

The six printed circuit boards located on the top of the main chassis and the printed circuit boards in the power unit are inserted into edge connectors and are therefore removable. The printed circuit boards on the underside of the main chassis are directly wired but are hinged to allow for easy component replacement and access to assemblies and components positioned under the boards.

Access to the screened assemblies is obtained by removal of screws holding the respective covers, and since TF 2301A is usually supplied for mounting on a 19 inch rack, flanges and handles are fitted to the front panel for this purpose; ventilating top and bottom covers are fitted for purpose of protection.

The dimensions of the instrument are as follows :

Width : 483 mm (19 inches) including flanges.
Depth : 406 mm (16 inches) not including controls and handles.
Height : 178 mm (7 inches).
Weight : 16 kg (36 lb).

1.3 ELECTRICAL CHARACTERISTICS

R. F. INPUT

Frequency range :	4 MHz to 1000 MHz on f. m. Usable to higher frequencies at a reduced r. f. input sensitivity. 4 MHz to 500 MHz on a. m.
R. F. input level :	The instrument has an a. l. c. system which allows the input to be within the range determined at the lower end by the sensitivity and at the higher end by the maximum safe input, without further adjustment. The levelling system comprises a linear control loop acting on the i. f. amplifier, and an up/down counter setting the r. f. input attenuator.
Hold attenuator :	When the instrument is used in the programmable mode the attenuator setting may be held after the instrument has adjusted to a particular r. f. input level. This facility enables subsequent measurements to be made more rapidly. The r. f. level must remain to within +6 dB and -3 dB of the initial value.
Sensitivity :	Better than 500 mV on f. m. (Typically better than 250 mV.) Better than 25 mV on a. m. (Typically better than 12 mV.) These levels apply for a constant local oscillator level of 800 mV e. m. f. from a 50 Ω generator. When a low noise (e. g. crystal controlled oscillator) local oscillator is used the sensitivity on f. m. can be increased to 25 mV by removal of a link connection within the instrument. This action does not increase the inherent f. m. noise.
Maximum safe input :	0.5 W. (5 V r. m. s. for a c. w. signal.)
Input impedance :	Nominally 50 Ω.

1.3 continued

LOCAL OSCILLATOR: The instrument requires an external generator for use as the local oscillator.

Level : 800 mV ±2 dB, e.m.f. from a 50 Ω source.

Frequency range : 5.5 MHz to 1001.5 MHz. The local oscillator should be tuned to 1.5 MHz above the r.f. input frequency.

NOTE : Any noise from the external oscillator will contribute to the residual noise level of the TF 2301A.

I.F. OUTPUT

Centre frequency : 1.5 MHz.

Level : Approximately 500 mV.

Output impedance : Nominally 10 kΩ.

F.M. MEASUREMENT

Deviation range : 6 ranges with full-scale indications of 1.5 kHz, 5 kHz, 15 kHz, 50 kHz, 150 kHz and 500 kHz.

Selection of positive or negative deviation measurements.

* The de-emphasis must be switched off when measuring deviation on the 1.5 kHz deviation range.

Modulation frequency : 30 Hz to 200 kHz on deviation ranges 5 to 500 kHz.

30 Hz to 3.4 kHz on 1.5 kHz deviation range.

Measurement accuracy : ±3% of full-scale (±4% using meter readout) for deviations 5 kHz to 500 kHz, at modulation frequencies from 30 Hz to 150 kHz.
±10% of full-scale for deviations up to 500 kHz at 150 kHz to 200 kHz.
±5% of full-scale on 1.5 kHz deviation range.

A.M. rejection : The additional deviation error, when a.m. depth is 80% and the modulating frequency is 1 kHz, is typically less than 300 Hz in a 15 kHz bandwidth.

Inherent noise : Using a low noise local oscillator, the residual deviation is less than 25 Hz for a bandwidth of 30 Hz to 15 kHz measured at the l.f. output using an r.m.s. voltmeter.

Calibration : A front panel preset control is provided for f.m. calibration of the instrument against the internal standard.

1.3 continued

A.M. MEASUREMENT

Modulation depth range :	2 ranges with full-scale indications of 30% and 100% (maximum usable measurement 95%).
Modulation frequency :	30 Hz to 50 kHz.
Measurement accuracy :	±3% of full-scale (±4% using meter readout) for modulating frequencies from 30 Hz to 15 kHz, and modulation depths up to 80%. ±5% of full-scale for modulating frequencies from 30 Hz to 50 kHz, and depths up to 95%.
Calibration :	A front panel preset control is provided for a.m. calibration against a suitable EXTERNAL 50% a.m. standard.

L.F. OUTPUT

Bandwidth on f.m. :	30 Hz to 200 kHz on deviation ranges 5 to 500 kHz. 30 Hz to 3.4 kHz on 1.5 kHz deviation range. The bandwidth can be restricted to 15 kHz with a switchable low-pass filter. This filter also restricts the deviation measurement bandwidth.
Bandwidth on a.m. :	30 Hz to 50 kHz.
De-emphasis :	Selection of 0, 50, 75 and 750 μs.
Distortion on f.m. :	Less than 0.2% (typically less than 0.1%) for deviations up to 75 kHz with modulation frequencies up to 15 kHz. Less than 0.3% (typically less than 0.2%) for deviations up to 300 kHz and modulation frequencies up to 25 kHz. Less than 3% (typically less than 2%) for deviations up to 500 kHz and modulation frequencies up to 200 kHz.
Distortion on a.m. :	Less than 1% (typically less than 0.5%) for a.m. depths up to 60%. Less than 3% (typically less than 1%) for a.m. depths up to 90%.

1.3 continued

Level : Nominally 0 dBm (775 mV) into 600 Ω load for full-scale on both a.m. ranges, and all f.m. deviation ranges, except the 1.5 kHz deviation range.

Nominally -10 dBm (245 mV) into 600 Ω load on the 1.5 kHz deviation range.

Output impedance : Nominally 600 Ω.

D.C. OUTPUT : The d.c. output is proportional to modulation.

On a.m. : 0.1 V for full-scale on 100% full-scale range.

0.3 V for full-scale on 30% full-scale range.

On f.m. : 0.5 V for full-scale on 5, 50 and 500 kHz full-scale ranges.

1.5 V for full-scale on 1.5, 15 and 150 kHz full-scale ranges.

Output impedance : Less than 1 kΩ. The output is intended for use with a high impedance voltmeter.

The d.c. output is available in the Programmable and Manual mode. The panel meter is normally inoperative in the Programmable mode - see below.

CONTROL

Programmable mode : Mode selected by panel switch. Programmable operation is not affected by manual control settings, except by the 'set calibration' controls. A 'press to read meter' switch is provided. Control is by b.c.d. (1-2-4-8 weighting) data applied to connector on the rear panel.

Control function	No. of lines
FM/AM	1
±DEVIATION or PEAK/TROUGH	1
MODULATION RANGE	3
DE-EMPHASIS	2
MAX. MOD. FREQ.	1
HOLD ATTENUATION	1

1.3 continued

Input levels (see also Optional accessories):

'0' state is 0 V to +5 V, or short circuit to common, sinking 9 mA maximum.

'1' state is +9 V to +25 V or open circuit.

Setting time: 5 s maximum from when the r.f. and l.o. signals are applied.

This may be reduced to 500 ms for subsequent measurements if the r.f. input level is maintained, and the hold attenuation function is used; e.g. when checking a.f. response, ± deviation, etc.

Manual mode: Mode selected by panel switch. Incoming b.c.d. information is ineffective on Manual operation. Manual working is by front panel controls.

CONNECTIONS: All connections to the instrument are to the rear panel.

POWER REQUIREMENTS

A.C. mains: 95 V to 130 V or 190 V to 260 V. 45 to 65 Hz, 60 VA.

1.4 ACCESSORIES

Supplied:

43122-017 Mains lead.

34461-305 Shorting link.

Ether Ltd., 14 way free socket, type no. MRAC 14S-JTC2-1A00H with pins.

31815-115 Extender board, 12 way, double sided.

31815-116 Extender board, 24 way, single sided.

Optional:

TM 9884 R.F. Fuse Unit.

43168-008 Shielded adapter (GE 51002).

4007-003 Bench use modification kit.

TK 7084/3 Logic level converter module.

Chapter 2 OPERATION

2.1 INTRODUCTION

Measurements using TF 2301A can be performed either automatically, by application of programmed signals or manually by setting the panel controls.

Both automated and manual operation is described.

2.2 CONTROLS AND CONNECTORS

The following outlines the functions of the manual controls located on the front panels of the instrument. The panel controls are inoperative when the instrument is switched to perform automatic tests.

2.2.1 Switch panel

(1) A.C. SUPPLY SWITCH : Lit when depressed to switch ON.

(2) MAN/AUTO SWITCH : Lit when depressed for MANUAL operation.

2.2.2 F.M./A.M. Modulation meter

(1) FUNCTION SWITCH : Enables TF 2301A to be set to cover the required f.m. or a.m. measurements.

(2) METER RANGE SWITCH : Selects f.s.d. reading of meter, i.e. five ranges for f.m. deviation, two for a.m. depth.

(3) DE-EMPHASIS SWITCH : Selects de-emphasis ranges i.e. OFF - 50, 75 and 750 μs. The DE-EMPHASIS switch must be at OFF when measuring deviation on the 1.5 kHz range.

(4) MAX MOD FREQUENCY SWITCH : Sets maximum bandwidth on f.m., i.e. 15 kHz or 200 kHz.

(5) F.M. CAL and A.M. CAL : Front panel preset controls providing for f.m. calibration against internal standard and a.m. calibration against external standard.

(6) READ METER SWITCH : Press to read meter when operating in AUTO mode.

2.3 INSTRUMENT CONNECTORS

All inputs and outputs are conveyed through connectors located on the rear panel of the instrument. Connectors are allocated as detailed below :

(1) SKAA (BNC fixed socket) : Accepts the r.f. input signal. Input impedance nominally 50 Ω. The maximum average input power for c.w. or a frequency modulated signal is 0.5 W i.e. 5 V into 50 Ω.

With amplitude modulation the r.f. power increases as the depth of modulation is increased e.g.: with a modulation depth of 100% the power is increased by 1.5, therefore, for 100% modulation the max. c.w. input should be 333 mW i.e.: 4 V into 50 Ω.

(2) SKAB (BNC vixed socket) : Accepts the external oscillator signal. Input impedance nominally 50 Ω.

(3) SKAC (BNC fixed socket) : The i.f. signal 1.5 MHz at 500 mV (nominal). Output impedance 10 kΩ.

(4) SKAD (BNC fixed socket) : The d.c. output from SKAD is passed to the auto system or alternatively to a high impedance voltmeter

(5) PLBA (14 way) : Control signals (b.c.d. inputs) for programmed operation of TF 2301A are conveyed through this connector. +18 V and +5 V are also available through this connector for use by logic level converting circuits.

(6) TERMINALS

TP1 : Connected to chassis. Normally not required when instrument is incorporated in an automatic test system.

TP2 : This terminal serves to connect the instrument control common, together with similar terminals on other instruments to a star earthing point on the system. TP1 must be connected to TP2 when using TF 2301 as an independent manually operated instrument.

TP4 : L.F. output - (high).

TP5 : L.F. output - (low connected to chassis).
L.F. output impedance 600 Ω (nominal).

Terminals TP4 and TP5 spaced to accept screened adapter to BNC (GE 51002).

(7) A.C. INPUT PLUG : The a.c. supply is conveyed through this 3 pin plug. The third pin is common to chassis.

2.4 MATING CONNECTORS

The following mate with the plug and sockets on the rear panel :

(1)	PLBA :	Ether 14-way socket MRAC14S-JCT2-1A00H, (supplied).
(2)	SKAA, SKAB, SKAC, SKAD :	BNC - 50 Ω free plug.
(3)	A.C. INPUT PLUG :	Bulgin Type P430/SE, (supplied).

2.5 FUSES

Supply 95/130 V :	2 A (slow blow).
190/264 V :	1 A (slow blow).
Mod meter +12 V :	500 mA.
-18 V :	500 mA.
Control +18 V :	3.15 A.

2.6 A.C. VOLTAGE SELECTOR SWITCH

Selects either 95 to 130 V or 190 to 264 V.

2.7 A.C. SUPPLY CABLE

The free a.c. supply cable is fitted at one end with a female plug which connects with the instrument. When fitting the supply plug ensure that the conductors are connected as follows :

Earth - Green/Yellow

Neutral - Blue

Line - Brown

2.8 PRELIMINARY REQUIREMENTS (Manual and Auto)

Prior to connecting the instrument to the a.c. supply check that :

(1) Voltage selector switch is set to accept the local supply (voltage regulation eliminates transformer tap changing except between 95/130 V and 190/264 V ranges). To change the range, remove locking plate, set switch, reverse plate and refit.

(2) Fuses are of the required rating, not open circuit, and secure in the holders.

(3) Meter pointer is at zero. If necessary, adjust the screw on the meter to set the pointer at mechanical zero.

(4) Terminals TP1 and TP2 are connected together with the link provided when TF 2301A is used as an independent bench instrument.

2.9 SELECTION OF FUNCTIONS AND RANGES

When TF 2301A is switched for automatic operation programmed b.c.d. signals are applied through PLBA to the control circuits for function and range selection and the panel controls are then inoperative.

When the instrument is switched for manual operation the signals applied to the control circuits are then only dependent upon the setting of the panel switches.

The b.c.d. inputs required to be applied to PLBA to set up the instrument for automatic measurements are given in Table 2.1.

TABLE 2.1

Note : Pin R is at 0 V (control common)

Function and Range		Pins on PLBA A	B	C	D	E	F	H	J	K	L
Hold Attenuator								1			
A.M. Measurements			1								
F.M. Measurements			0								
Max Mod 15 kHz									1		
150 kHz									0		
Modulation Range	1.5 kHz			0	0	0					
	5 kHz			1	0	0					
	15 kHz - 30% A.M.			0	1	0					
	50 kHz - 100% A.M.			1	1	0					
	150 kHz			0	0	1					
	500 kHz			1	0	1					
De-emphasis	OFF									0	0
	50 μs									1	0
	75 μs									0	1
	750 μs									1	1
F.M. Deviation + or A.M. Peak							0				
F.M. Deviation - or A.M. Trough							1				

Pin M is wired to the logic board but this line is normally held inoperative by a connection to 0 V within TF 2301A.

This connection can be removed when a low noise local oscillator is used, and it is required to increase the r.f. sensitivity on f.m. from 500 mV to 25 mV.

The connection is on Pin 2 on the logic control board 3860/138.

Pins N and P are used for control outputs +5 V, +18 V respectively.

2.9 continued

When TF 2301A is installed in an automatic system the required local oscillator frequencies for r.f. carrier inputs 4 to 1000 MHz are usually provided by a programmable signal generator. However, a crystal controlled oscillator with an output of 800 mV e.m.f. (nominal) operating at a frequency 1.5 MHz above the r.f. carrier frequency can be used as the local oscillator for repeated measurements at a fixed carrier frequency

2.10 AUTOMATIC MEASUREMENTS

Configuration Fig. 2.1 shows the general form of an automatic test system and operation is briefly described.

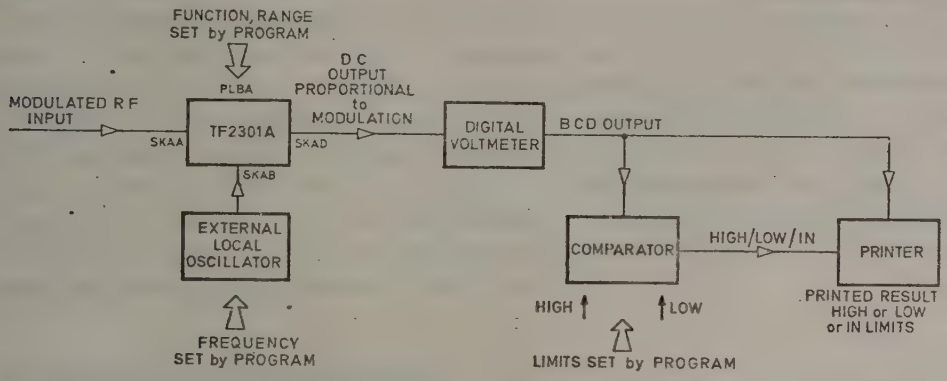


Fig. 2.1 : basic system for programmed tests

The controller causes programmed b.c.d. inputs to be applied to PLBA to select the function and measurement range of TF 2301A and at the same time causes a local oscillator signal at the required frequency to be applied to SKAB; upper and lower test limits are applied to the comparator for the test.

When a modulated r.f. carrier is applied to the input SKAA on TF 2301A a d.c. analogue output proportional and numerically equal to the f.m. deviation or a.m. depth is passed from output SKAD to a digital voltmeter (d.v.m.) where it is converted to digital form.

The digital output from the d.v.m. is then applied to the limits comparator where it is referenced against programmed limits which are predetermined to cover an expected f.m. deviation or a.m. depth. The printer records a voltage level which is directly proportional to modulation and if this is greater or less than the preset limits an H (high) or L (low) sign is added to the printed result.

2.11 RESPONSE TIMES

After application of the modulated r.f. and local oscillator signals the time required for the TF 2301A to settle is less than 5 seconds provided that the instrument has not been saturated by application of a modulated signal in excess of the modulation range setting.

Saturation of TF 2301A is more likely to occur on f.m. than a.m. For example: a deviation of 500 kHz could be present with the instrument set on the 1.5 kHz range, whereas with a.m. the maximum possible modulation depth is limited to 100% and the most sensitive range is 30%, consequently saturation effects are limited.

Typical saturation recovery times are 1 second for a x10 overload and 2 seconds for an overload of x100.

2.11 continued

To reduce the possibility of saturation, the TF 2301A should be programmed for the maximum modulation/deviation range prior to measurements being made. The required measurement range should then be programmed immediately before the modulated r.f. and local oscillator signals are applied, or alternatively, the r.f. input may be unmodulated and the required range set prior to modulation being applied.

For repeated measurements on a particular unit, e.g. modulation frequency response of a transmitter, the time to complete each individual measurement can be reduced to 500 ms by programming the 'hold attenuator' function immediately after the TF 2301A has adjusted to the r.f. input signal level (5 seconds). It is essential that the r.f. input remains uninterrupted for the series of measurements. Any level change, as could be incurred e.g. with a transmitter warming up, should not exceed +6 dB and -3 dB of the initial level. The hold attenuator signal should be removed when the r.f. input is disconnected to ensure that TF 2301A is conditioned to enable adjustment to subsequent signal inputs.

2.12 SETTING F.M. CALIBRATION

Prior to using the instrument in either automatic or manual mode for f.m. measurements it is necessary for maximum accuracy to correctly set the meter calibration using the internal calibrator.

The procedure is as follows :

(1) Depress the SUPPLY switch and the MANUAL switch.

(2) Set the FUNCTION switch at FM-SET CAL and the METER RANGE switch to any range other than 1.5 kHz deviation.

(3) Check that the meter pointer is at the SET mark.

(4) If necessary, adjust the associated 'set calibration' potentiometer (accessible through aperture on front panel) to position the meter pointer at the SET mark.

2.13 AUTOMATIC MEASUREMENT OF F.M. DEVIATION

Note:

Ensure that DE-EMPHASIS is not called when measuring deviation on 1.5 kHz range.

(1) Switch TF 2301A for PROGRAMMED operation i.e. - MANUAL switch not depressed and unlit.

(2) Program MODULATION RANGE for 500 kHz.

(3) Program LOCAL OSCILLATOR for a signal of 800 mV e.m.f. (from 50 Ω source) at a frequency 1.5 MHz above the frequency of the carrier. Apply the local oscillator signal to SKAB.

2.13 continued

(4) Program MODULATED R.F. to input SKAA.

(5) Program METER RANGE according to expected deviation.

(6) Program MAX MOD for 15 or 200 kHz as required.

(7) Program F.M. DEV +.

(8) Program DELAY of not less than 5 seconds.

(9) Program HOLD ATTENUATOR (for repeated measurements see 2.11).

(10) MEASURE and RECORD the d.c. output at SKAD.

The d.c. output at SKAD represents the maximum frequency deviation above the carrier frequency; i.e. +DEV.

(11) Without interrupting the r.f. input signal program for DEV-.

The d.c. output at SKAD now represents the maximum frequency deviation below the carrier frequency and the time required to complete the measurement is not greater than 500 ms.

If the recorded results for DEV+ and DEV- are not equal then asymmetric modulation of the carrier frequency is indicated.

To ensure that asymmetry is a function of the input signal and not introduced by the instrument set the local oscillator frequency at 1.5 MHz below the carrier frequency. If the asymmetry is reversed the asymmetric modulation can be attributed to the input signal.

2.14 MANUAL MEASUREMENT OF F.M. DEVIATION

Note:
Set DE-EMPHASIS at OFF for measurements on 1.5 kHz deviation range.

(1) Switch TF 2301A for manual operation i.e. MANUAL switch depressed and lit.

(2) Set METER RANGE switch according to the expected deviation and the MAX MOD switch to select the required bandwidth.

(3) Apply a local oscillator signal of 800 mV e.m.f. at a frequency 1.5 MHz above the carrier frequency to SKAB, and the modulated carrier signal to SKAA.

(4) Set the FUNCTION switch at TUNE OSCILLATOR and adjust the oscillator tuning for a rapid rise of the meter pointer to the SET mark.

2.14 continued

(5) Set the FUNCTION switch at FM-SET FREQ then carefully readjust the oscillator tuning to reset the meter pointer exactly at the SET mark.

(6) Set the FUNCTION switch at DEV+. Maximum frequency deviation above the carrier frequency is indicated on the scale of the panel meter.

(7) With the same r.f. input level set the FUNCTION switch to DEV-. Maximum frequency deviation below the carrier frequency is indicated on the scale of the panel meter.

2.15 AUTOMATIC MEASUREMENT OF A.M. DEPTH (Carrier inputs 4 to 500 MHz)

(1) Check that TF 2301A is switched for automatic measurements, i.e. MANUAL switch not depressed and unlit.

(2) Program METER RANGE for 30% or 100% a.m. according to the expected modulation depth of the carrier.

(3) Program for a local oscillator signal of 800 e.m.f. at a frequency 1.5 MHz above the applied carrier frequency.

(4) Program the modulated carrier to socket SKAA.

(5) Program for A.M. PEAK.

(6) Program DELAY of not less than 5 seconds.

(7) Program HOLD ATTENUATOR (for repeated measurements see 2.11). MEASURE and RECORD.

The d.c. output at socket SKAD represents the percentage modulation depth at PEAK

(8) Without interrupting the r.f. input signal, program for A.M. TROUGH.

The d.c. output at socket SKAD now represents the percentage modulation depth at TROUGH, and the time required to complete the measurement is not greater than 500 ms

If unequal indications are obtained there is distortion in the input signal - see Section 2.13.

2.16 MANUAL MEASUREMENT OF A.M. DEPTH

(1) Switch TF 2301A for MANUAL operation, i.e. MANUAL switch depressed and lit.

(2) Set METER RANGE switch at 30% or 100% a.m. according to the expected modulation depth of the applied signal.

(3) Apply a local oscillator signal of 800 mV e.m.f. at a frequency 1.5 MHz above the carrier frequency to SKAB and the modulated carrier signal to SKAA.

(4) Set the FUNCTION switch at TUNE OSCILLATOR and adjust the oscillator tuning for a rapid rise of the meter pointer to the SET mark.

(5) Set the FUNCTION switch at AM-SET FREQ then carefully readjust the oscillator tuning to reset the meter pointer exactly at the SET mark.

2.16 continued

(6) Set the FUNCTION switch in turn at A.M. PEAK and A.M. TROUGH.

The percentage modulation depth at peak and trough is indicated on the appropriate scale of the panel meter for the respective setting of the switch.

2.17 MEASUREMENT OF F.M. ON A.M.

For automatic or manual measurement of f.m. on an amplitude modulated carrier, the instrument is set up as for f.m. measurement (sections 2.13 or 2.14) but with an amplitude modulated signal applied to SKAA.

A certain amount of spurious f.m. is introduced by the instrument when the carrier is deeply modulated at high modulating frequencies and this should be taken into consideration.

Below 40% depth over the audio range of frequencies the spurious f.m. is small. At 80% depth and a modulation frequency of 1 kHz, the maximum f.m. is typically less than 300 Hz referred to the 15 kHz bandwidth.

Tables 2.2 and 2.3 which give typical expected f.m. on a.m. are for general guidance only.

Table 2.2

Spurious f.m. deviations with increasing % a.m.

MOD frequency = 1 kHz

A.M. %	Spurious deviation	
	15 kHz bandwidth	200 kHz bandwidth
30	75 Hz	750 Hz
80	300 Hz	2 kHz

Table 2.3

Spurious f.m. deviations with increasing a.m. frequency

A.M. depth = 80%

Mod freq.	Spurious deviation	
	15 kHz bandwidth	200 kHz bandwidth
1 kHz	300 Hz	2 kHz
10 kHz	1 kHz	3 kHz
100 kHz	-	7 kHz

2.18 MEASURING A.M. ON F.M.

The modulation meter can be used to indicate amplitude modulation of a frequency modulated signal provided that the deviation is less than 100 kHz. The procedure is that of a.m. measurement (sections 2.15 or 2.16) but with f.m. signals applied to SKAA.

Below 100 kHz deviation, the internally generated spurious a.m. is less than 2%.

In general, the spurious a.m. indication will be proportional to the deviation. The i.f. amplifier is set up for optimum phase response for f.m. deviation measurement rather than a maximally flat response for measuring a.m. on f.m.

2.19 L.F. OUTPUT

CAUTION. Application of d.c. to the l.f. output terminals by externally connected equipment will cause damage.

External test equipment can be connected to the L.F. OUTPUT terminals TP4 - TP5 to measure modulation frequency response, analyse modulation distortion, or measure the level of residual modulation due to noise or spurious signals as described in sections 2.20 and 2.21. With a sufficiently sensitive external meter measurements at the L.F. OUTPUT can be extended down to the residual noise level of the TF 2301A. For noise measurements, the desired bandwidth can be obtained by a suitable capacitor or filter between the L.F. OUTPUT terminals.

The facility for using the instrument as a test receiver is furthered by the provision for switching standard de-emphasis capacitors of 50 μsec, 75 μsec or 750 μsec into the circuit of the l.f. amplifier.

Since the l.f. output is supplied from a buffer amplifier, loading the terminals does not affect the accuracy of the analogue output and meter reading.

It is recommended that the l.f. output be terminated with 600 Ω,: when unterminated, there is a slight deterioration of the level response, and due to leakage of C11, a small d.c. voltage will be present which can cause difficulty if a d.c. coupled oscilloscope at high sensitivity is connected to the terminals.

The l.f. signal corresponding to full-scale is nominally 0 dBm. However, because the instrument ranging is in 10 dB steps, the l.f. output is 0.46 dB lower on the 15 kHz (30% a.m.) and 150 kHz ranges than on the 5 kHz, 50 kHz (100% a.m.) and 500 kHz ranges. On the 1.5 kHz range the output is -10 dBm at full-scale.

2.20 RESIDUAL F.M. DEVIATION MEASUREMENTS

When measuring low values of deviation produced by noise or spurious signals, the measurements should be made using an external r.m.s. voltmeter connected to the L. F. OUTPUT, terminals TP4 and TP5. The TF 2301A detector being peak reading, is not ideally applicable to noise measurements: also it may not be sufficiently linear when measuring deviations of less than 1% of the selected full-scale range.

A recommended meter is the Marconi Instruments Programmable R.M.S. Voltmeter TF 2607 which has the necessary sensitivity to allow f.m. noise measurements to be made to an accuracy limited only by the inherent noise level of TF 2301A.

The TF 2301A has two selectable f.m. bandwidths i.e. 15 kHz and 200 kHz and within these bandwidths the frequency response is flat, see fig. 3.2 and sections 3.15 and 3.16. When noise measurements within a specific bandwidth are to be made, a corrective capacitor or filter should be connected between the L. F. OUTPUT terminals.

For noise measurements in a 15 kHz bandwidth select the 15 kHz filter and connect a 0.014 μF capacitor between the terminals, and for a 150 kHz bandwidth select the 200 kHz filter and connect a 0.0013μF capacitor between the terminals. The response of the 15 kHz filter with the corrective capacitor connected is as Fig. 2.2: it is shown that the l.f. response then approximates the ideal filter

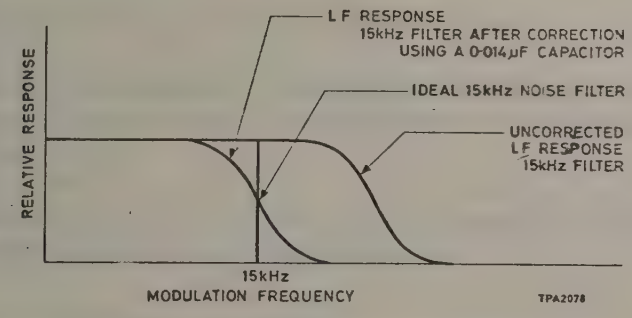


Fig. 2.2 :

For optimum results in the 15 kHz bandwidth a low-pass filter, as shown in Fig. 2.3, should be used between the OUTPUT terminals and the external meter instead of the capacitor. This removes any remaining i.f. signal.

continued

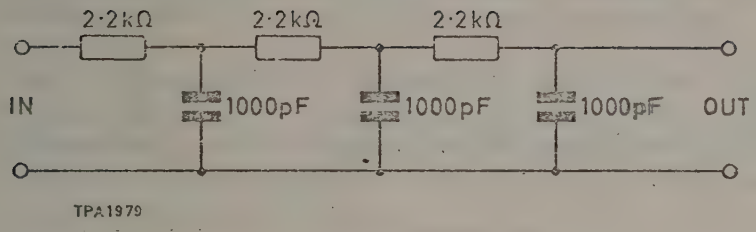


Fig. 2.3 : Low-pass filter

For noise measurements in other bandwidths the 200 kHz filter should be selected and a similar type of low-pass filter designed to provide the required cut-off frequency.

When performing noise measurements, the inherent noise of the TF 2301 must be taken into consideration, and this will largely depend on the inherent noise level of the local oscillator.

It should be noted that when using the l.f. output the output level corresponding to full-scale is only nominally 0 dB and can vary by 0.5 dB on alternate full-scale ranges - see Section 2.19.

2.21 AUTOMATIC SIGNAL + NOISE TO NOISE TEST

This test which is basically a ratio measurement is performed to prove that spurious modulation produced by the inherent noise of the unit under test is within the specified limit.

Configuration Fig. 2.4 shows the general arrangement for an automatic measurement and the principle is briefly described.

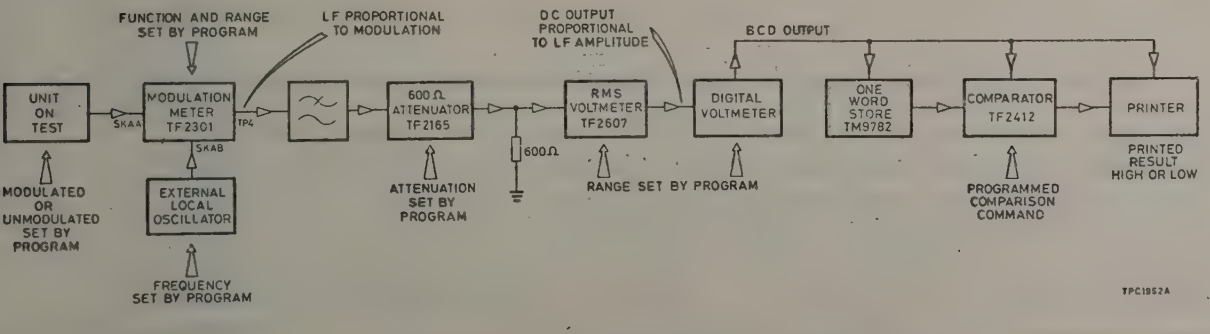


Fig. 2.4 : Automatic noise measurements

continued

(1) The d.c. output from the r.m.s. voltmeter is digitized by the d.v.m. and passed to the one word store where it is held to be used as a reference and upper limit for the subsequent noise measurement.

(2) The modulating signal is removed and the sensitivity of the measuring system is increased by X dB to correspond with the specified noise figure of the transmitter. This produces a second digitized output from the d.v.m. which is passed to the comparator where it is compared with the digitized reference (upper limit) from the store.

When the output (procedure 2) is shown to be less than that set as an upper limit by procedure 1 the S/N ratio will be within specification.

The automatic test procedure is basically as follows :

(1) Program the TF 2301A (function, range and bandwidth), the attenuator TF 2165 (to a value equal to the S+N/N ratio specification), the r.m.s. voltmeter TF 2607 (range), and the D.V.M. (range), to cover the predetermined f.m. deviation or a.m. depth.

(2) Program for the unit on test to be modulated at the reference level required.

(3) Program for a delay of 5 seconds plus a further delay for the integration time required by the r.m.s. voltmeter.

(4) Program the D.V.M. reading to be held in the one word store.

(5) Program for the modulating signal to be removed from the unit on test and for the attenuation following TF 2301A to be removed.

(6) Program for a delay as in (3).

(7) Program for the D.V.M. reading to be compared with the reading in the one word store as the upper limit.

(8) Print the result. If the second measurement is low the unit on test is within specification, if high, it is out of specification.

2.22 MANUAL SIGNAL + NOISE TO NOISE TESTS

For manual measurements of signal + noise to noise ratio $\frac{S+N}{N}$, the only instrument required in addition to TF 2301 is an r.m.s. voltmeter of suitable sensitivity (1 mV/full-scale enables measurements to 60 dB down on full-scale of any TF 2301 modulation range). Errors due to crest factor and zero shift in the voltmeter can be avoided by operating the meter at mid-scale, if necessary by using an external attenuator. When an r.m.s. voltmeter is not available an average reading instrument can be used: a correction of +1 dB should then be applied.

2.22 continued

The test procedure is as follows:

(1) Depress the MANUAL switch which should be lit.

(2) Set the TF 2301A METER RANGE as required for the reference modulation level from the unit under test.

(3) Set the MAX MOD switch at the required setting and further adjust the noise measurement bandwidth by adding an external filter or capacitor across the L. F. OUTPUT terminals as described in Sect. 2.20.

(4) Set the voltmeter range to 1 V and shunt the input with 600 Ω.

(5) Apply the modulated r. f. input to TF 2301A and adjust the modulation until the desired reference level is obtained.

(6) Note the voltmeter reading on the dB scale.

(7) Remove the modulation from the unit under test and increase the voltmeter sensitivity until the reading due to noise modulation only is as near as possible to the reading obtained in (5).

(8) The difference between the reading in (5) and (6) in dB plus the increase in voltmeter sensitivity in dB gives the $\frac{S+N}{N}$ ratio in decibels.

2.23 PHASE MODULATION MEASUREMENT

To ascertain the degree of phase modulation, measure the f. m. deviation and divide by the modulation frequency to obtain the answer in radians.

Chapter 3 TECHNICAL DESCRIPTION

3.1 INTRODUCTION

This chapter, which outlines the overall and circuit functions of the instrument, should be read with reference to circuit diagrams and drawings contained within this manual.

The instrument is set up to perform each required measurement by programmed b.c.d. commands applied to control circuits which operate relays.

For programmed operation, the b.c.d. inputs are applied to the control circuits through connector PLBA and for manual operation by the setting of the panel switches.

Changeover from automatic to manual operation is achieved by depressing a switch which causes three relays to be operated to provide the required mode.

Interconnection of the various units employed in TF 2301A is shown on Drawing No. Z46465-004.

3.2 SUMMARIZED OVERALL FUNCTION

Overall function of the instrument,which is briefly described, is shown in the block schematic diagram Drawing No. Y46465-004, sheet 1.

The f.m. or a.m. signal applied to the input socket SKAA is passed to the mixer through an attenuator consisting of three series connected π pads - 7.5 dB, 15 dB and 30 dB.

Output from an external oscillator is applied to the mixer through socket SKAB to produce an i.f. signal of 1.5 MHz.

The i.f. signal from the mixer is then applied to the i.f. amplifier through a variable gain control stage which is set by the automatic level control system.

When measuring f.m. the output signal from the i.f. amplifier, Fig. 3.1(a), is applied to a limiter, the output of which is as shown in Fig. 3.1(b). The limited i.f. signal is then applied to a pulse counter type discriminator circuit which produces positive-going pulses of constant amplitude and width as Fig. 3.1(c).

These pulses have a mean amplitude Vm which varies directly as the modulation frequency, Fig. 3.1(d). The mean amplitudes are then d.c. restored as in Fig. 3.1(e) and the a.c. is applied to the first l.f. amplifier.

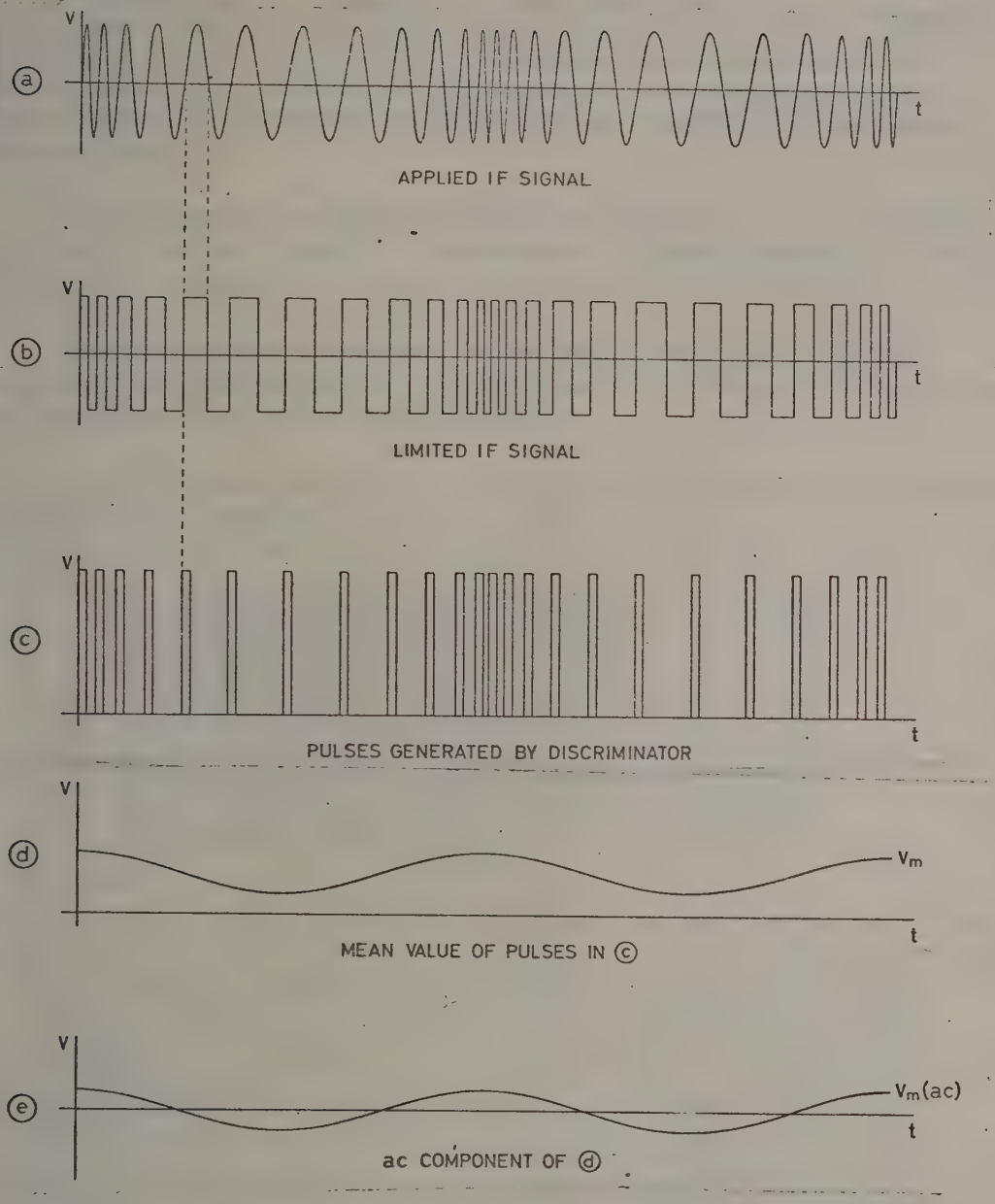


Fig. 3.1 : Operation of discriminator

Output from the first l. f. amplifier is passed to the meter range potentiometer either through a series resistor when the carrier deviation is greater than 15 kHz or through a low-pass filter when the carrier deviation is less than 15 kHz.

The selected output from the meter range potentiometer is passed to a transistor operating as an emitter follower to apply the signal to the second l. f. amplifier.

3.2 continued

Output from either the first or second stage of the second l.f. amplifier is passed to a peak detector circuit. The output from the detector is d.c. proportional to f.m. deviation or a.m. depth and this is applied to socket SKAD for automated measurements or to the panel meter circuit for manual measurements.

When measuring amplitude modulation the output from the i.f. amplifier is applied to the a.m. detector. The detected l.f. signal is applied to a 50 kHz low-pass filter through an attenuator used to set the a.m. calibration.

The 50 kHz filter removes any remaining i.f. and passes only the l.f. to the meter range potentiometer. From the 50 kHz filter output, the measurement function is the same as that described for f.m.

Typical response curves for l.f. output with de-emphasis OFF are shown in Figs. 3.2, 3.3 and 3.4.

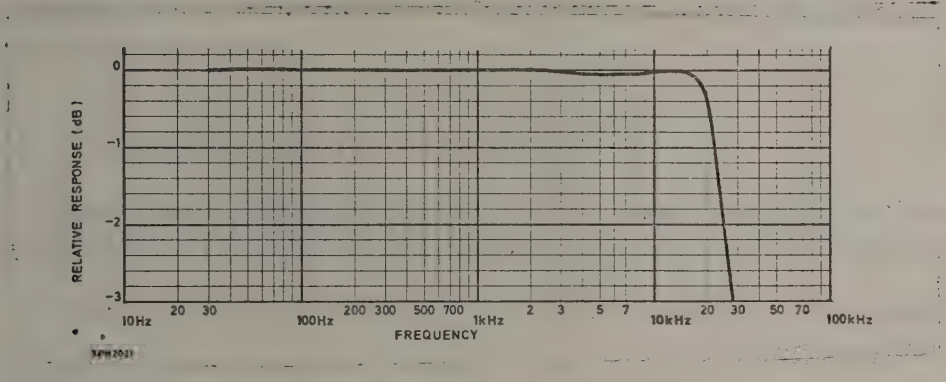


Fig. 3.2 : Typical demodulated f.m. frequency response with internal 15 kHz filter in circuit

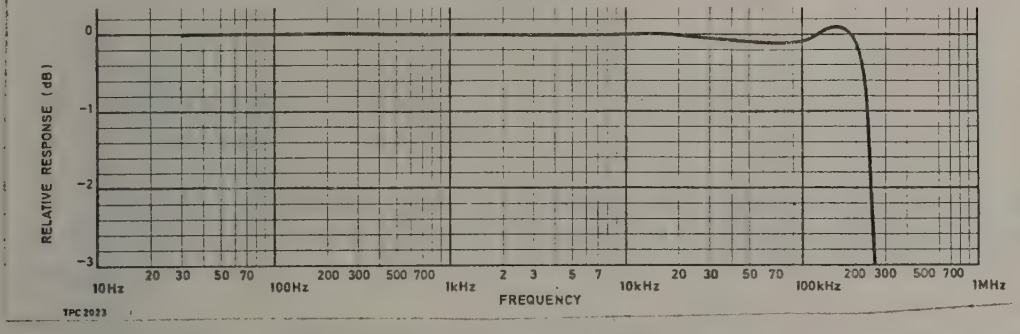


Fig. 3.3 : Typical demodulated frequency response with internal filter out of circuit

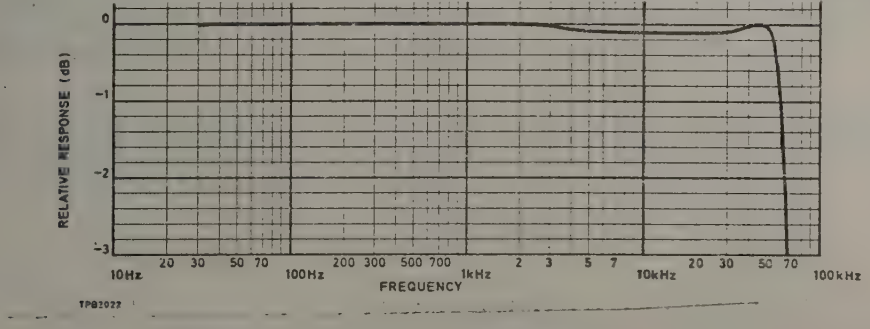


Fig. 3.4 : Typical demodulated a.m. frequency response

3.2 continued

The automatic level control system (a.l.c.) functions to maintain the level of the input signal to the mixer within preset limits and to hold the output level of the i.f. amplifier precisely at 0.5 V r.m.s. - see Section 3.6.

The squelch circuit prevents a high level of random noise from being present when an input signal is not applied to SKAA. In consequence, the long recovery times which would be experienced when operating the instrument in the automatic mode, are avoided.

When making a.m. measurements the r.f. signal level in the mixer is kept low to ensure that the a.m. envelope is not distorted by the frequency changing process

For f.m. measurements the r.f. signal level is increased by nearly 30 dB since mixer distortion does not deteriorate the measurement whilst the increased level is advantageous in that the effect of noise introduced by the internal (local) oscillator is considerably reduced.

3.3 SUMMARIZED CIRCUIT FUNCTIONS

The schematic drawing No. Y46465-004, sheet 1, sections the circuits employed in TF 2301A and shows the basic interconnections and switching.

The following sections briefly describe the function of each circuit.

3.4 INPUT ATTENUATOR
(Circuit diagram Z 44425-516)

The input attenuator, which is contained in a cast aluminium case, consists of three series connected π pads providing attenuated levels of 7.5 dB, 15 dB and 30 dB.

The setting of the attenuator is dictated by b.c.d. outputs from an up-down counter which is fundamentally controlled by the automatic level control system. The b.c.d. outputs from the counter cause solenoids to be operated to actuate microswitches which determine the attenuator setting.

When a r.f. signal is applied to input SKAA the attenuator is automatically set to maintain the r.f. input to the mixer within preset limits.

3.5 MIXER
(Circuit diagram C 44412-030)

The mixer, which accepts the r.f. and local oscillator signals, is an untuned square law converter using a point contact silicon diode.

It is contained in a separate compact case to provide complete screening and since inputs and outputs are conveyed through short lengths of coaxial cable spurious responses caused by stray pick-up are reduced to a low level.

The local oscillator signal is obtained from an external source connected through socket SKAB.

3.6 AUTOMATIC LEVEL CONTROL
Circuit diagram Z 44826-626

The a.l.c. board 3860/163 consists of three sections :

(1) I.F. attenuator.

(2) Gain controlled i.f. amplifier.

(3) A.M. detector.

(4) Control loop amplifier.

The automatic level control (a.l.c.) circuit operates to maintain the output of the i.f. amplifier at 0.5 V for all levels of r.f. input up to 5 V.

Overall circuit operation and the function of individual circuits are briefly described. The overall description can best be followed with reference to the functional diagram Y46465-004, sheet 1.

Overall operation

The output from the i.f. amplifier (see Z 44823-280) is applied to the a.m. detector, resulting in a l.f. modulation signal and a d.c. voltage proportional to the mean level of the i.f. signal. The d.c. component is passed to the control loop amplifier where it is compared with a preset reference level. The loop amplifier produces an output voltage proportional to the error signal, which is passed to the gain controlled i.f. amplifier, to set the gain. Provided the i.f. input level is within certain limits, the overall i.f. gain will be automatically varied to maintain 0.5 V at the i.f. output, i.e. the input to the a.m. detector.

The gain controlled amplifier delivers a d.c. voltage that is proportional to the change in gain. This voltage is passed to the r.f. input attenuator control circuit (see Z44846-222 where it is compared with upper and lower preset limits. If the voltage level is outside these limits, an up-down counter is started to cause the r.f. input attenuation to be increased or decreased in 7.5 dB steps until the i.f. input signal level is within the control range of the gain controlled amplifier. When this occurs, the gain sensing voltage falls within the limits of the comparator in the attenuator control circuit, causing the up-down counter to stop, and the r.f. attenuation to be held at the value attained at the instant the counter is stopped.

The control loop is set up to ensure that the variation in i.f. signal level to the gain controlled amplifier does not exceed 11.25 dB. Consequently since the r.f. attenuato is stepping by increments of 7.5 dB the system has a backlash of 3.75 dB which prevents instability in the control system when the r.f. input level corresponds to the upper or lower threshold levels for starting the counter.

The time constant R16 - C6 of the control loop around the i.f. amplifier is long to ensure that control of the mean i.f. level is maintained when the signal is amplitude modulated at low frequency.

The i.f. attenuator at the input to the gain control stage is switched into circuit for f.m. measurement. When connected, it influences the action of the a.l.c. loop to increase the signal input to the mixer.

A.M. Detector circuit

The i.f. signal applied to the a.m. detector circuit is first amplified by the differential pair using transistors in IC1 and then by the differential circuit TR1-TR2 to provide a signal to an emitter follower, the base-emitter junction of which, in conjunction with the filter circuit C3, R13, C5, forms a conventional envelope detector with linearity improved by feedback to one input of the first differential pair.

The l.f. output from the detector is passed to the l.f. amplifiers whilst the d.c. component which is proportional to the level of the i.f. signal is applied to the loop amplifier through the stabilizing time constant.

Loop Amplifier

This is also a differential amplifier which uses two transistors in IC1 to compare the level of the d.c. component from the a.m. detector (proportional to the level of the i.f. signal) with a d.c. level preset by R24.

The differential d.c. outputs from the collectors which are limited by diodes D1 and D2 are applied to the gain controlled amplifier.

Gain Control Amplifier

The gain controlled amplifier employs four transistors which are contained in IC2 and the circuit configuration is basically that of a long tailed pair with a constant current tail.

Gain of the amplifier and consequently the outputs i.e. sense level output and i.f. output are controlled by the d.c. levels applied to the inputs of the long tailed pair.

Transistors TR3 and TR4 supply a d.c. level (proportional to the i.f. level) via a potentiometer to the panel meter when the FUNCTION switch is in the TUNE position. The potentiometer is preset to position the meter pointer at the SET mark when the instrument is correctly tuned.

3.7 SQUELCH CIRCUIT
(Circuit diagram Z 44823-277)

The squelch circuit is necessary to prevent noise output from the discriminator when r. f. is not applied to input SKAA. If the squelch circuit was not included, the overload recovery time after connection of an r. f. signal to SKAA would be such that automated measurements would be considerably delayed. The squelch circuit, which is described, also operates to prevent saturation of the l. f. amplifiers due to a sudden change in d. c. level at the discriminator output that would otherwise occur when the r. f. input is removed.

Normally (with r. f. applied to SKAA) the sense level input to the squelch circuit is such that transistor TR3 is ON and transistors TR1 and TR2 are OFF.

Under these conditions, current flows from the limiter circuit (Circuit No. Z44823-279) allowing normal operation of the limiter and with TR1 in the OFF condition bias current to the 200 kHz filter is removed.

When the r. f. is removed from SKAA the sense level is virtually at ground potential (positive) and with this condition TR3 is OFF and transistors TR1 and TR2 are ON. This causes the current to the control transistor in the limiter circuit to be removed and consequently the limiter is prevented from operating and current is applied to the 200 kHz filter to maintain the d. c. level which is normally resident when the i. f. signal is present.

The variable resistor, R5, is adjusted so that the d. c. level output from the 200 kHz filter is the same for signal/no signal conditions. This ensures that the l. f. amplifiers do not receive a transient when the r. f. input is removed as this could saturate these amplifiers and disrupt the measurement which follows.

3.8 I. F. AMPLIFIER
(Circuit diagram Z 44823-280)

The i. f. amplifier consists of three stages coupled through band-pass filters. Primary requirements are a flat amplitude - frequency response, and a linear transfer characteristic for a. m. measurements and a linear phase - frequency response for f. m. measurements. No limiting occurs in the amplifier, and linearity, frequency response and the overall gain of 29 dB are stabilized by the negative feedback loops in each stage.

Output from the i. f. amplifier is passed to the input of the a. m. detector, to the limiter input, and to the I. F. OUT socket SKAC through a resistor and capacitor. The amplifier is contained in a screened compartment located close to the oscillator compartment.

3.9 LIMITER CIRCUIT
(Circuit diagram Z 44823-279)

The limiter consists of three emitter coupled amplifiers which operate to limit signal amplitudes of either polarity. The emitters are connected to balancing potentiometers to equalize the excursion in each direction. Part of the limited i.f. signal is tapped off from the third amplifier (see Fig. 3.5(a)), differentiated by C7 and L1 (see Fig. 3.5(b)) and detected by MR1 to produce the uni-directional pulses shown in Fig. 3.5(c).

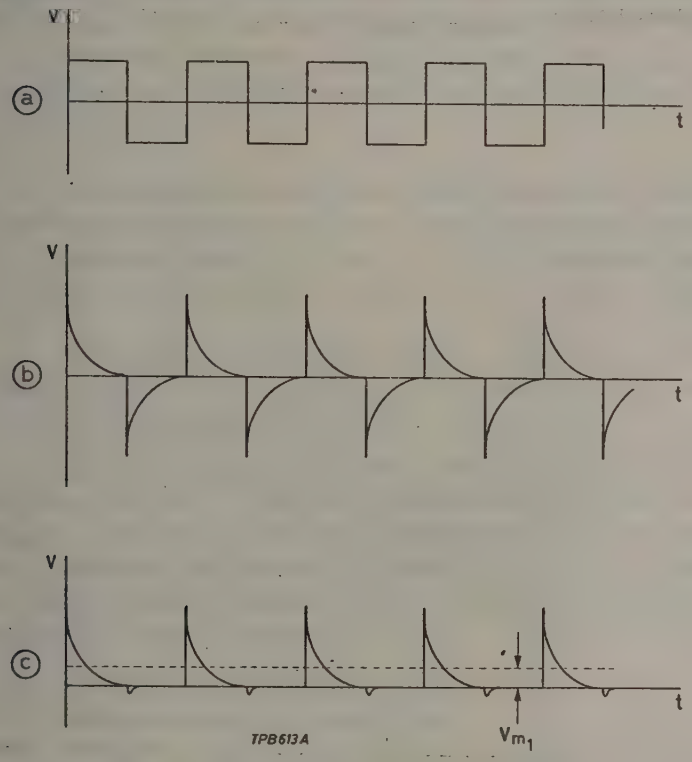


Fig. 3.5 : Operation of limiter

These pulses have a d.c. term (Vm) almost directly proportional to the repetition frequency. When the instrument is at SET FREQ the d.c. is passed directly to the panel meter which indicates SET when the i.f. is correct.

The presence of any appreciable degree of carrier shift when modulation is applied to the input signal will be indicated by the panel meter when the FUNCTION switch is at F.M. SET FREQ. The amount of shift can be measured with a counter at I.F. OUT (SKAC) provided that the gate time is long with respect to the period of the modulating signal or is equal to an integral number of periods.

Transistor VT7 and associated components R25, MR2, MR3 form the circuit which prevents the limiter from operating when r.f. is not applied to the input of the instrument.

When an input signal is connected to SKAA an output from the squelch circuit (Section 3.7) is passed to the base of VT7 causing this transistor to conduct and return the emitters of transistors VT3-VT4, VT5-VT6, to 0 V and the limiter is operational.

When an r.f. input is not connected to SKAA there is no output from the squelch circuit; consequently VT7 is OFF and the limiter is inoperative. The limiter is contained in a screened compartment in the centre of the underside of the chassis.

3.10 DISCRIMINATOR UNIT
(Circuit diagram Z 44823-282)

The pulse counter type discriminator occupies the rear half of the screened compartment on the underside of the chassis and consists of a trigger amplifier, a Schmitt trigger circuit, a pulse generator and a pulse clipping circuit.

The limited i.f. signals (Fig. 3.1(b)) are first applied to the trigger amplifier, VT1. Diode MR1 removes the negative part of the i.f. signals and RV1 is adjusted to set the Schmitt circuit VT2 and VT3 at the point of regeneration. Every time the limited i.f. signal passes through zero in a positive-going sense, a large square wave with constant rise and fall times is produced at the output of the Schmitt circuit.

These square waves are then differentiated by C4 and R10 and the negative overshoot is removed by MR2. The differentiated square waves are then passed to a pulse generator, VT4 and VT5, which together with the pulse clipper, VT6, produces a series of pulses which are of constant amplitude and width (see Fig. 3.1(c)).

These pulses have a mean value, Vm, (Fig. 3.1(d)) which will vary directly with the modulation frequency. The low frequency variation of the mean value of the pulses is passed to VT7.

VT7 is an emitter follower which ensures a low output impedance from the discriminator. The signal is passed to the 200 kHz low-pass filter unit where a 1 kΩ series resistor is included to correctly match the filter. The filter removes the pulses and outputs l.f. on a d.c. level as Fig. 3.1(e). The low frequency change in the mean value of the pulses is therefore passed and the i.f. signal rejected.

3.11 ATTENUATOR CONTROL CIRCUITS
(Circuit diagram Z 44846-222)

The attenuator control board consists of:

(1) A sensing circuit (comparator).

(2) A clock generator (multivibrator).

(3) An up-down counter.

(4) Three solenoid driver circuits.

The sensing circuit (Drawing No. Z 44846-222) consists of two differential amplifiers (i.c. package) which through associated transistor circuits cause one of two relays RLA or RLB to be operated.

Operation of either RLA or RLB is determined by the level of the input signal from the sense line and the potentiometers RV1 and RV2 are preset for upper and lower limits.

3.11 continued

When the input level is greater than the preset upper limit, relay RLA is operated and its then open contacts cause the counter to perform a 'count up'; this adds attenuation to the r.f. level applied to the mixer through input SKAA. When the input level is less than the preset lower limit, relay RLB is operated and its then open contacts initiate a 'count down'; this reduces attenuation to increase the r.f. level applied to the mixer.

A multivibrator providing pulses at intervals of approximately 200 ms serves to clock the counter. Outputs from the counter are connected to transistor circuits which drive solenoids, these in turn operate microswitches in the attenuator block to set the attenuator.

The circuit of the counter which employs nine i.c. packages (IC1 to IC9 inclusive) is shown in Drawing No. Z 44896-222 and the function is illustrated in Fig. 3.7 and Fig. 3.8.

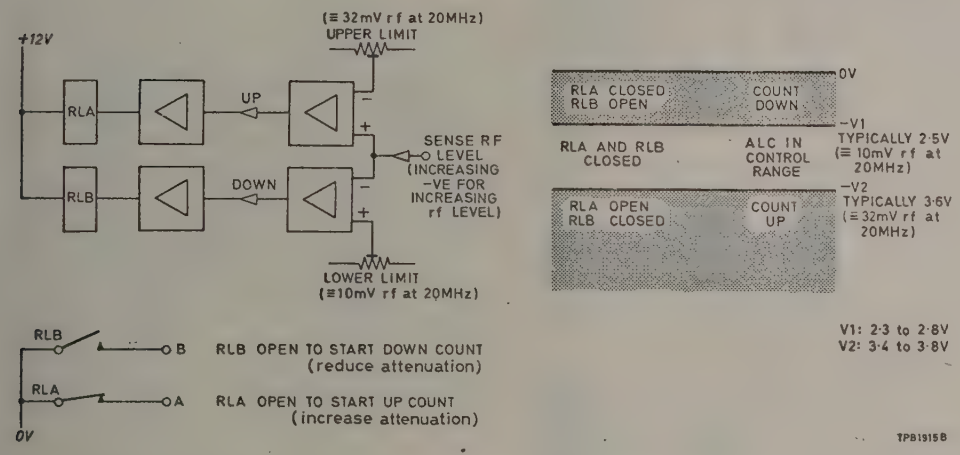
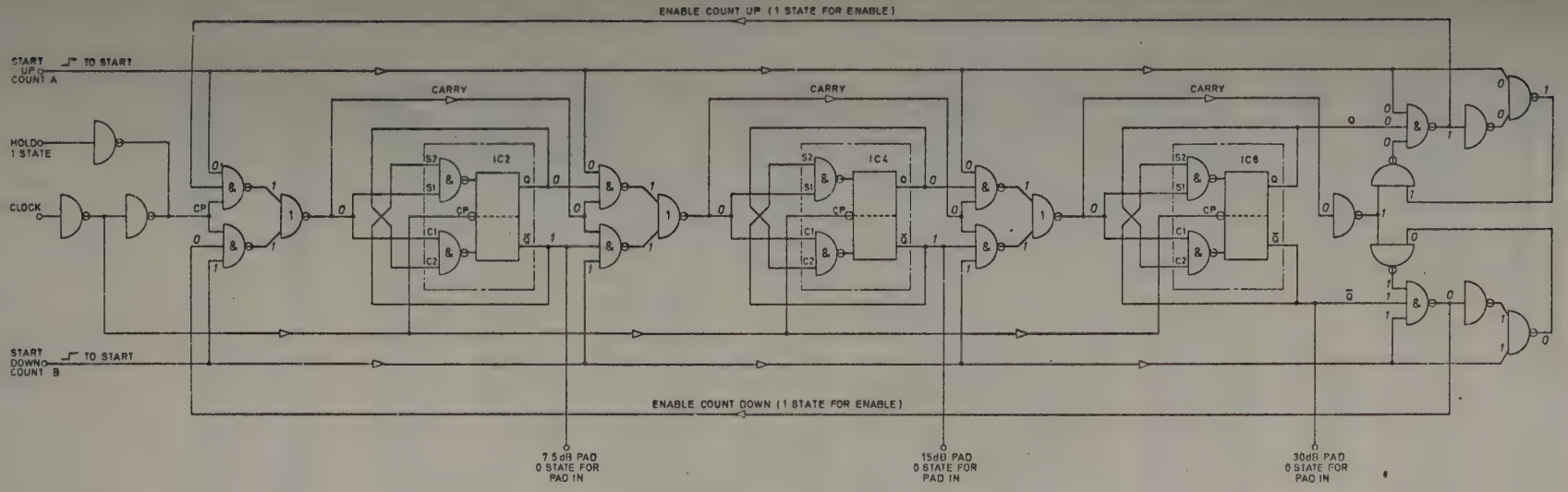
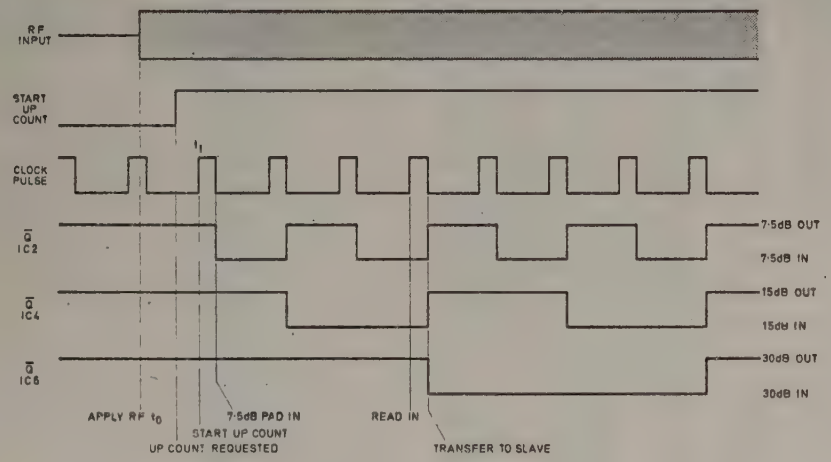


Fig. 3.7 : block diagram of up-down counter

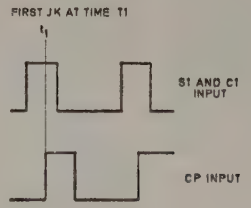




JK TRUTH TABLE

t_n		t_{n+1}
S1	C1	Q
0	0	Q_n
1	0	1
0	1	0
1	1	$\overline{Q}_n$

Figures in italics are logic states for instrument in steady state with no r.f. input. ie - down count completed and enable lines reset for up count.



TPD1914

Fig. 3.8 Circuit and waveforms up/down counter

3.12 1st L. F. AMPLIFIER
(Circuit diagram Z 44822-133)

Demodulated signals from the discriminator are passed to the first l. f. amplifier through the 200 kHz low-pass filter.

The amplifier consists of three stages, the circuit of VT1 operates as a voltage amplifier and the circuit of VT2 as an emitter follower serving the output stage employing transistors VT3 and VT4.

The amplifier is designed to provide a wide bandwidth and constant gain with immunity from supply voltage changes.

Capacitor C6 introduces positive feedback to part of the circuit to increase the effective loop gain. Both a. c. and d. c. negative feedback is passed from the amplifier output to input by C5, R7, R8 and the SET CAL F. M. control to (a) hold the gain constant at a predetermined level and (b) to stabilize the d. c. conditions.

The output stage employing transistors VT3 and VT4 in conjunction with negative feedback via C5 is designed to have a very low output impedance. This output impedance is then increased to 1 kΩ by R14 to correctly terminate the 15 kHz filter. Negative feedback to the base of VT1 forms a 'virtual earth' at this point and series resistor R2 then increases the input impedance to 1 kΩ to correctly terminate the 200 kHz filter.

3.13 2nd L. F. AMPLIFIER
(Circuit diagram Z 44824-405)

The function of transistors VT1 and VT2 in the first section of this amplifier is similar to that of the first two transistors in the first l. f. amplifier and variable resistor RV1 in the feedback loop sets the gain.

The second section is a buffer amplifier circuit which provides 0 dBm into 600 Ω at the L. F. OUTPUT terminals TP4 - TP5.

The output signal from the first section on deviation ranges 5 to 500 kHz is passed to the peak detector through switching circuits on the relay board.

On the 1. 5 kHz range additional gain is obtained by using the output from the buffer section. Since this amplifier contains the de-emphasis components it is important to switch these out of circuit when measuring deviation on this range.

The output impedance at the terminals is 600 Ω (nominal) and d. c. should not be applied to the terminals by externally connected equipment since the coupling capacitor, C11, is a low voltage electrolytic.

3.14 DE-EMPHASIS CAPACITORS

The four capacitors used for de-emphasis are located on the relay board (circuit diagram Z 44843-607) and are switched into circuit by relay contact closure.

3.15 200 kHz LOW-PASS FILTER
(Circuit diagram Z 44414-137)

Output from the discriminator is passed to this filter which removes the pulses and passes l. f. on a d. c. level as in Fig. 3. 1(e). Since the output is capacitively coupled to the first l. f. amplifier the d. c. component is removed.

When an r. f. signal is not applied to SKAA, the squelch circuit passes a bias current through the filter source resistor R1 which provides a voltage equal to that which is present with an r. f. signal is applied.

3.16 15 kHz LOW-PASS FILTER
(Circuit diagram XC 42795)

Output from the first l. f. amplifier is connected to the meter range potentiometer through either a series resistor or the 15 kHz filter.

The 15 kHz filter limits the l. f. bandwidth of the instrument and enables satisfactory f. m. measurements to be made at deviations in the audio band. It is also used to limit the bandwidth of the L. F. OUTPUT for narrow band noise measurement - see Section 2. 20.

3.17 50 kHz LOW-PASS FILTER
(Circuit diagram B 44843-136)

When measuring a. m. the output from the a. m. detector is connected through a preset potentiometer to this filter which removes any remaining i. f. signal.

3.18 METER RANGE POTENTIOMETER
(Circuit diagram Z 44843-607)

The meter range potentiometer consists of five series connected resistors which are located with the associated emitter follower on board 3860-13. Three of the resistors are paralleled with S. I. C. values for the purpose of calibration.

Range selection is provided by operation of relays M, N, P, Q, R, which are on the same p. c. board.

3.19 CALIBRATOR
(Circuit diagram Z 44824-406)

Internal calibrator 3860-160 which is contained in a screened compartment located on the chassis, produces a crystal controlled output which represents a ±200 kHz deviation at a repetition frequency of 2 kHz for standardizing the discriminator and l. f. circuits.

3.19 continued

Basic operation of the calibrator circuit is illustrated in Fig. 3.9 and described below.

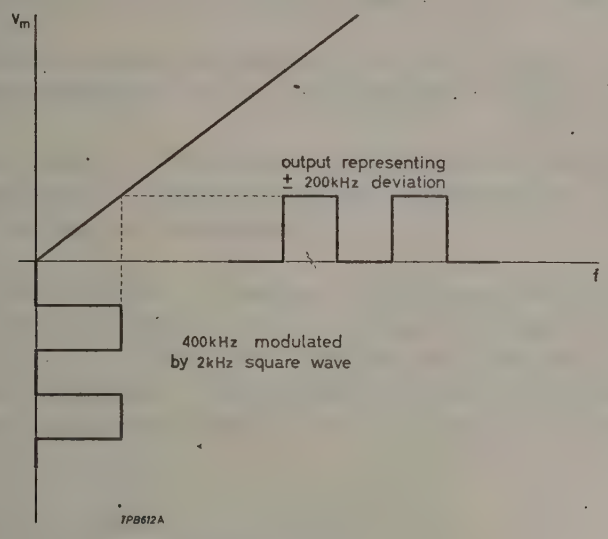


Fig. 3.9 : Operation of calibrator

Output from a multivibrator generating pulses at a repetition frequency of 4 kHz is applied to a binary divider (VT7 - VT8) through an emitter follower, VT4.

The binary divider provides 2 kHz pulses with a mark space ratio of 1 :1 and these are applied to a gating circuit (VT5 - VT6) to which is also connected the output from a crystal controlled oscillator.

The output from the gating circuit is a 400 kHz signal divided into bursts of r.f. at a repetition frequency of 2 kHz at a 1 :1 on/off ratio. This is applied to the discriminator and represents, for the purpose of calibration, a deviation of ±200 kHz. The calibrator is operated only when the instrument is at FM-SET CAL, when the related preset potentiometer on the front panel can then be adjusted to position the meter pointer at the SET mark.

3.20 PEAK READING VOLTMETER
(Circuit diagram Z 44824-645)

The peak reading voltmeter circuit consists of three sections:

(1) An amplifier which allows the signal level to be correctly set.

(2) An inverter which is switched in or out of circuit to enable measurements of peak and trough for a.m. or positive or negative deviations for f.m.

(3) A peak detector circuit (patent pending) which outputs d.c. to the panel meter and to output socket SKAD for connection to a digital voltmeter or other external equipment.

The circuit, which is designed to overcome certain disadvantages related to the usual method of measuring peak voltages, is especially applicable to programmed systems. The circuit design is such that the discharge time of the storage capacitor is considerably reduced, this enables faster measurement response to a change in peak amplitude and consequently a saving of time for a series of automatic tests.

3.21 LOGIC CONTROL
(Circuit diagram Z 44825-606)

Outputs from the gate circuits on board 3860-138 (which are in high level logic to provide noise immunity) operate relays which set the measurement function and measurement range of the instrument. The logic level inputs to the gates are applied either through connector PLBA for automatic measurements, or by the setting of the panel switches for manual operation.

Inputs and outputs of the logic control board are detailed on the circuit diagram.

The control circuits are constructed using i.c. packages, external diodes and transistors. The overall logic function is detailed in Drawing No. Y 46465-004, sheet 2.

3.22 RELAYS
(Circuit diagram Z 44843-607)

The final setting up of the instrument to perform each measurement is dictated by the operation of relays, the majority being located on board 3860-13. The function of each relay on the control board is given on the circuit diagram. The instrument is switched for automatic or manual operation by relays RLA, RLB and RLC which are located on the chassis - see Fig. 4.1. Relays on the p.c. board are operated by the logic outputs from the control board and the auto/manual relays are operated by the auto/manual switch.

3.23 POWER UNIT
(Circuit diagrams Z 44824-644 and Z 44822-134)

The power unit which is located at the rear of the chassis operates by switch selection from a.c. supplies of 95 to 130 V or 190 to 260 V - 45 to 65 Hz to provide stabilized outputs as follows:

+18 V, +12 V, +5 V	Board No. 3860-14
-18 V, -12 V	Board No. 3860-161

The +18 V and +5 V supplies are allocated to the logic circuits and the +12 V, -12 V and -18 V supplies serve the signal circuits. The logic and signal supplies are completely independent. The 0 V related to the signal circuit supplies is connected to terminal TP1 CHASSIS but the 0 V related to the logic circuits is connected to terminal TP2 - CONTROL COMMON which is isolated from chassis (floating).

The d.c. stabilizing circuits are contained on p.c. boards 3860-14 and 3860-161, Drawing Nos Z 44824-644 and Z 44822-134.

Interconnections are shown in Drawing No. Z 46465-004.

Chapter 4 MAINTENANCE

4.1 INTRODUCTION

This chapter contains information to enable the performance of the instrument to be maintained. It should be read with reference to Chapter 3 and the drawings and circuit diagrams contained within this manual.

CAUTION. This instrument uses semiconductor devices which, although having inherent long term reliability and mechanical ruggedness, are susceptible to damage by overloading, reversed polarity and excessive heat or radiation. Avoid hazards such as reversal of d.c. supplies, prolonged soldering, strong r.f. fields or other forms of radiation, use of insulation testers or accidentally applied short circuits. Even the leakage current from an unearthed soldering iron could cause trouble. Before shorting or breaking any circuit, refer to the circuit diagrams to establish the effect on bias arrangements of the transistors. It is essential that the instrument is switched OFF when inserting or removing a p.c. board.

4.2 SCREW FASTENERS

Screw threads used in this instrument are mainly metric but some BA sizes are included.

Cruciform headed screws are of the Posidriv pattern: to avoid damage a Posidriv screwdriver should be used.

Ensure that screws removed are refitted in original positions.

4.3 ACCESS AND LAYOUT

Figures 4.1 and 4.2 show the general location of sub-assemblies and p.c. boards above and below the chassis, when top and bottom protection covers are removed. Protective covers are attached by four screws.

Inter-unit connections and applied d.c. voltages are shown by the wiring diagram Drawing No. Z46465-004 and components on p.c. boards can be identified by reference to the drawings contained within this manual.

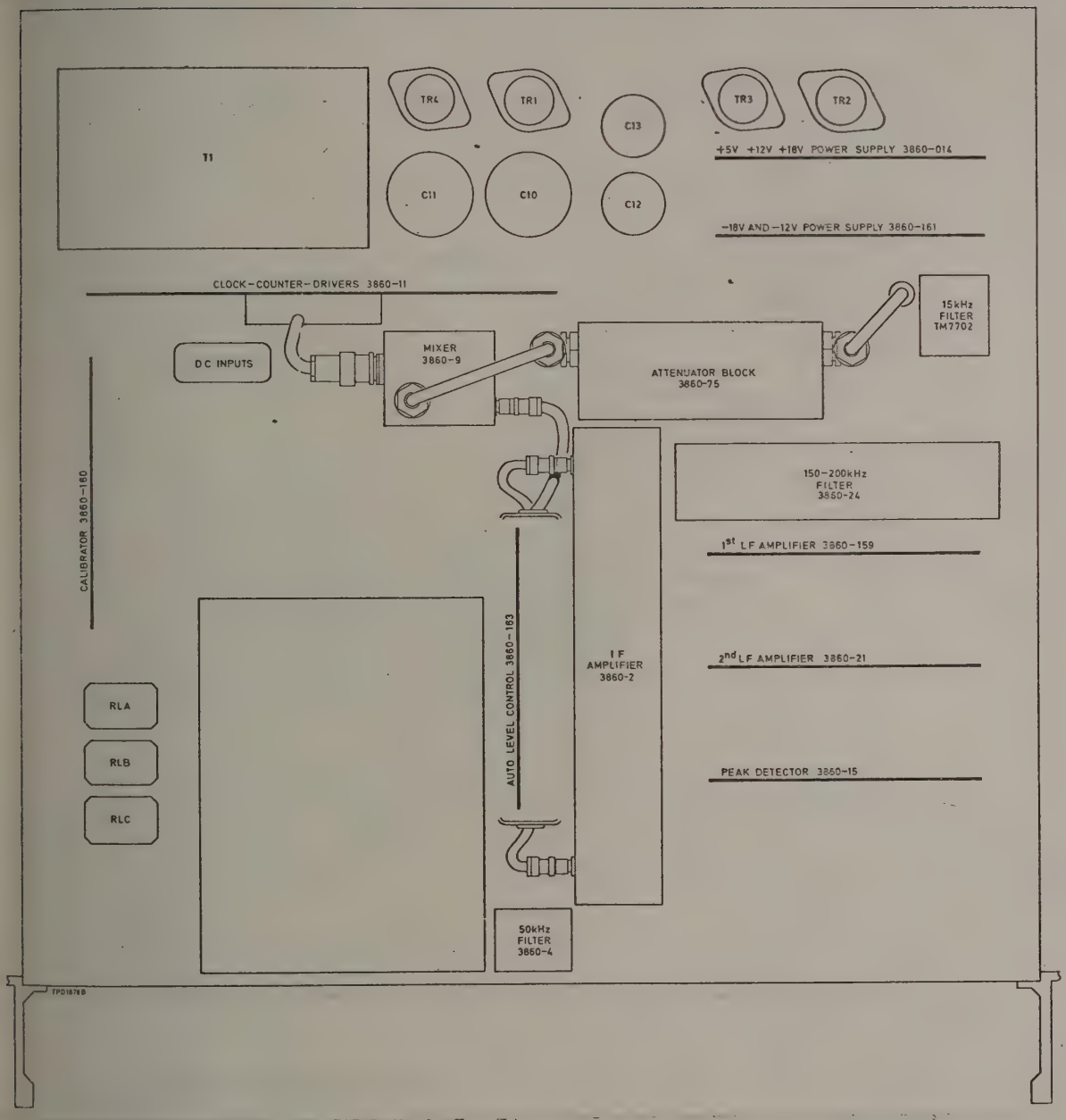


Fig. 4.1 : View of instrument from top with covers removed

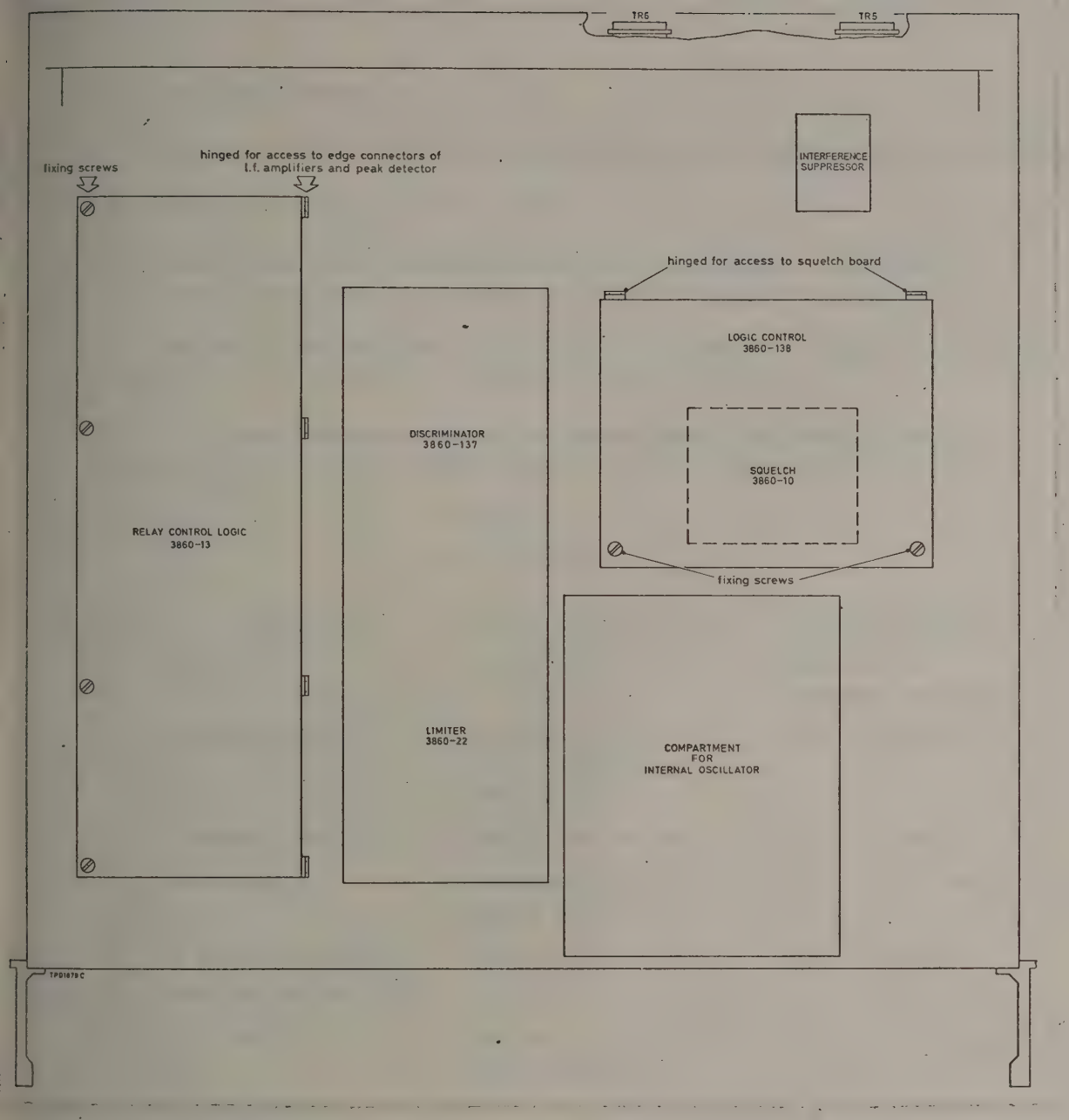


Fig. 4.2 : View of instrument from bottom with covers removed

4.4 PRELIMINARY CHECKS

(1) Periodic checks should be made to ensure that switches are operating correctly and inspection should be made to verify that all connectors are securely mated.

(2) Check that all fuses are of correct rating and type, not open circuit, and fit securely in the holders. Damage to the instrument can occur if fuses are replaced with the instrument switched on.

(3) Check, using the milliohmeter (k), that electrical connections to chassis and star points are of low contact resistance.

4.5 TEST EQUIPMENT

The test equipment required to perform the test described, is listed in Table 4.1.

4.6 OVERALL PERFORMANCE TESTS

Note: When testing TF 2301A independently i.e. on the bench, terminals TP1 and TP2 MUST be linked using shorting link supplied as an accessory.

The overall performance of TF 2301A can be quickly ascertained by application of signals of known deviation or modulation depth to SKAA.

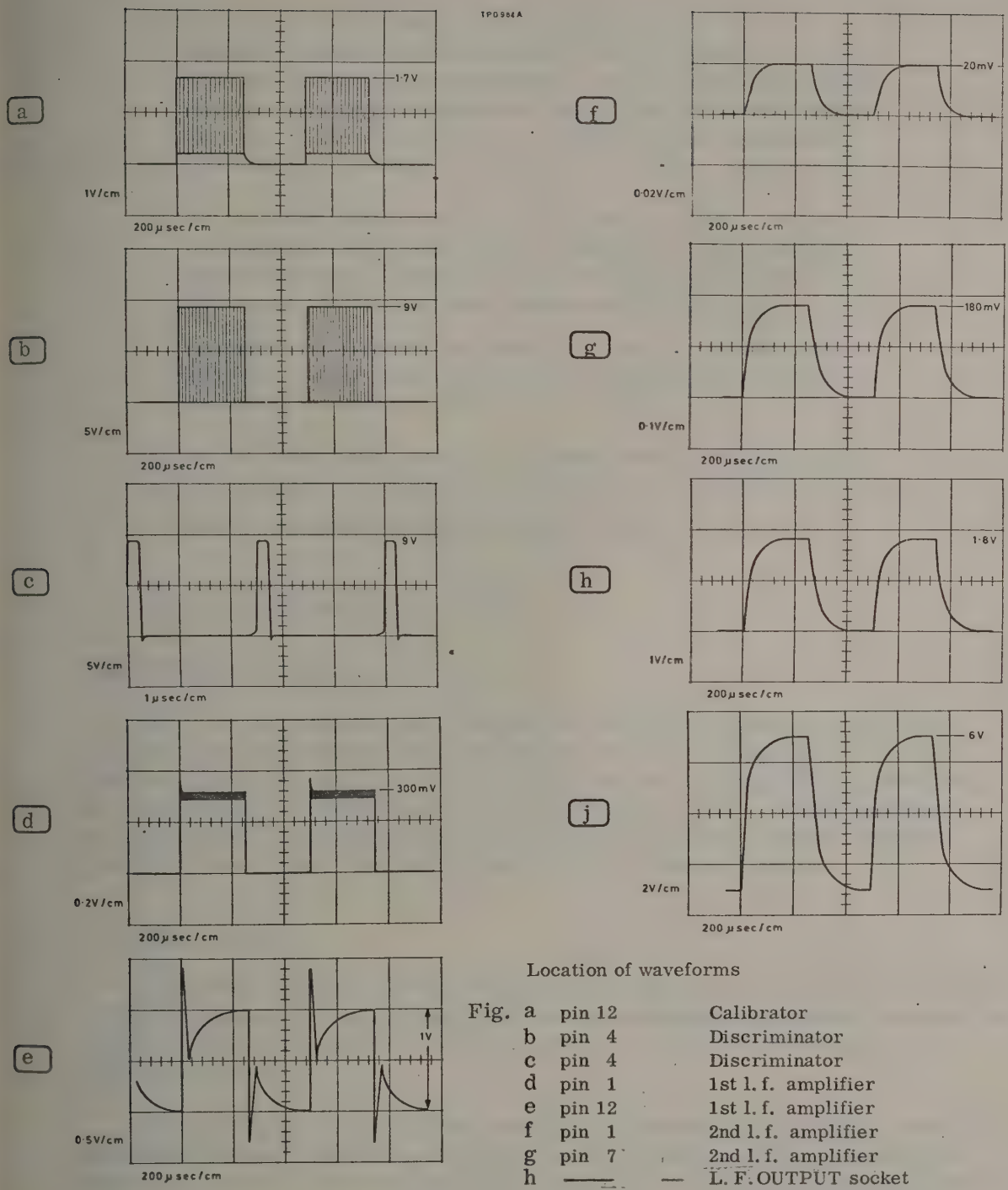
By following the measurement procedures given in Sections 2.14 and 2.16 the panel meter indications should correspond with the standard signals.

Table 4.1

Test equipment

Item	Instrument	Minimum specification	Recommended model
a	Multimeter	Range 0 to 25 V d.c.	Selectest or Avometer model 8.
b	Signal generator	Ranges 1 to 72 MHz A.M. 20 to 80% Outputs 0 to 1 V.	M.I. TF 2002AS.
c	Frequency counter	Range 1 to 50 MHz.	M.I. TF 2411.
d	Wave analyser	Frequency 50 to 150 Hz Inputs 0 to 500 mV.	M.I. TF 2330 or TF 2330A.
e	R.F. millivoltmeter	Ranges 0 to 1 V.	M.I. TF 2603.
f	Amplitude modulator		
g	L.F. oscillator	Ranges 15 Hz to 200 kHz. Outputs 0 to 1 V.	Wavetec. 155 or equivalent.
h	Oscilloscope		
j	Selective voltmeter	500 kHz to 100 MHz	Siemens Pegelmesser.
k	Milliohmeter		
m	Digital voltmeter (DVM)	0 to 25 V.	
n	50 Ω attenuator	0 to 60 dB.	M.I. TF 2163.
p	R.M.S. voltmeter		M.I. TF 2607.

The three tests (a), (b) and (c) given below, together with waveform checks at points listed in Fig. 4.3, will assist to quickly prove operation of the following circuits: calibrator, discriminator, 1st and 2nd l.f. amplifiers, peak-reading voltmeter and associated circuits.



Location of waveforms

Fig.			
	a	pin 12	Calibrator
	b	pin 4	Discriminator
	c	pin 4	Discriminator
	d	pin 1	1st l.f. amplifier
	e	pin 12	1st l.f. amplifier
	f	pin 1	2nd l.f. amplifier
	g	pin 7	2nd l.f. amplifier
	h	——	L.F. OUTPUT socket
	j	pin 5	Peak reading voltmeter

The conditions to obtain these waveforms are as follows:

DE-EMPHASIS switch to OFF. Function switch to SET CAL F.M. and TF 2301A switched for manual operation.

Fig. 4.3

4.6 continued

(a) Set the FUNCTION switch at FM-SET CAL.
The panel meter pointer should be at the SET mark.
If a meter indication is not obtained but the 2 kHz square wave of the calibrator is displayed on an oscilloscope connected at the L.F. OUTPUT terminals, the peak-reading voltmeter circuits are suspect.

(b) Set the FUNCTION switch at TUNE OSCILLATOR, apply an r.f. signal to SKAA and tune the external (local) oscillator to a frequency 1.5 MHz above the frequency of the applied r.f. for a rapid rise of the meter pointer to the SET mark.

If a meter indication is not obtained, apply a 1.5 MHz signal to SKAA. If the meter pointer is deflected then the local oscillator or mixer is faulty.

(c) Set the FUNCTION switch at FM-SET FREQ and carefully tune the oscillator to set the meter pointer precisely at the SET mark.

The i.f. output at SKAC should then be at 0.5 V r.m.s.

4.7 GENERAL PERFORMANCE TESTS

F.M. deviation accuracy

The f.m. deviation accuracy can be checked and, if necessary, can be set against the internal calibrator which provides a standard of long term stability. When the FUNCTION switch is set at FM CAL the internal calibrator is connected and the pointer of the panel meter should be at the SET mark. If the position of the pointer is incorrect, adjust the preset potentiometer accessible through the related aperture in the front panel to set the meter pointer correctly.

A.M. depth accuracy

An internal calibrator for checking the accuracy of a.m. depth is not included in TF 2301A, therefore it is necessary to use external equipment capable of providing a signal of accurately known modulation depth and of low envelope distortion to prove the instrument.

When a reliable standard is not available the measurement accuracy of the instrument for a.m. modulation depth can, with limitations, be checked using the signal generator (b), oscillator (g) and the selective voltmeter (j) in the configuration of Fig. 4.4.

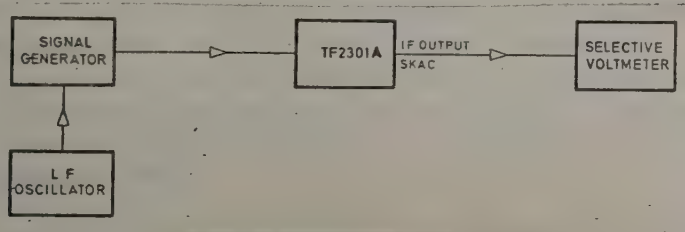


Fig. 4.4 : checking a.m. depth accuracy

4.7 continued

(1) Set the signal generator (b) for an output of 100 mV (nominal) at a selected frequency and with the l.f. oscillator (g) set at 3 kHz use it to modulate the signal generator to an indicated depth (initially using the signal generator meter) of 50%.

(2) Apply the signal generator output to socket SKAA on TF 2301A, Measure this signal as described in Sect. 2.16 then switch to A.M.-SET CAL.

(3) Connect the selective voltmeter (j) to the IF OUT socket SKAC on TF 2301A, tune the selective voltmeter to 1.5 MHz and set its attenuators to give a 0 dB reference.

(4) Retune the selective voltmeter to the upper sideband, decrease the attenuator readings by 6.04 dB then readjust the output of oscillator (g) to restore the meter reading to the 0 dB reference.

The pointer of the meter on the instrument should be at the SET mark. If incorrect, adjust the AM-SET CAL potentiometer (accessible through the related aperture in the front panel) to position the pointer correctly.

F.M. on A.M. test

An attenuated r.f. signal modulated at 1 kHz to a depth of 80% is applied to the R.F. INPUT socket of the instrument which is set to measure f.m. in a 15 kHz bandwidth. The spurious f.m. on a.m. is then indicated on the panel meter scale.

(1) Set the signal generator (b) to provide a signal of 500 mV at 30 MHz modulated to a depth of 80%, from the amplitude modulator (f) and apply this signal to the input socket SKAA.

(2) Set the FUNCTION switch at TUNE and adjust the frequency of the local oscillator for a rapid rise of the meter pointer to the SET mark.

(3) Set the FUNCTION switch at FM-SET FREQ and readjust the local oscillator tuning to position the meter pointer precisely at the SET mark.

(4) Set the FUNCTION switch at DEV+ and the RANGE switch and MAX MOD switch at 15 kHz.

The panel meter should indicate a deviation of less than 500 Hz.

Note: The above test is intended only as a check to ascertain that f.m. on a.m. is within the specified limits of the instrument. It is important that the attenuation inserted between the signal source and amplitude modulator (f) be maximum consistent with providing sufficient signal level. This is to ensure that reaction from the modulator does not cause f.m. on on a.m. in the signal generator. It is also important to verify that the external (local) oscillator is free from f.m. since,if this is present, it will be recorded by TF 2301A.

4.8 UNIT PERFORMANCE TESTS

The cause of incorrect performance can be localized by separately testing the various units employed in TF 2301A.

The following tests are performed with the instrument switched for MANUAL operation.

D. C. voltage tests

Connect the digital voltmeter (m), set to an appropriate range between points listed in Table 4.3 (a), (b) and (c), in turn, and verify that voltages are as given in (d) and (e).

Table 4.3

(a) +ve	(b) -ve	(c) Board No.	(d) Required voltage
Chassis	Pin 7	3860-161	18
Chassis	Pin 11	3860-161	12
Pin 3	Pin 1	3860-14	18
Pin 11	Chassis	3860-14	12
Pin 4	Pin 1	3860-14	5 (nominal)

Ripple and noise tests

Using the wave analyser (d) verify that ripple and noise components at 50 Hz, 100 Hz and 150 Hz on each d. c. line are not greater than that given in Table 4.4.

Table 4.4

D. C. line	Board No.	Max. ripple
-18 V	3860-161	100 μV
-12 V	3860-161	50 μV
+18 V	3860-14	1 mV
+12 V	3860-14	250 μV
+5 V	3860-14	1 mV

The tests are concerned with :

(a) Proving correct operation of the voltmeter circuit.

(b) The accuracy of the panel meter and correct function of the attenuator for ranging the analogue output.

(c) Since the instrument is primarily designed for use in automatic systems it is essential that the d.c. signal at socket SKAD be correctly proportional to and numerically equal to the modulation.

(1) Terminate the oscillator (g) with 50 ohms, set the frequency at 15 Hz, and the output to set the meter pointer at half scale; connect the output between PIN 5 (high) and PIN 2 (low) on 3860-15. A series connector capacitor (100 μF min) will be required for oscillators outputs which have continuity to earth.

(2) Set the panel controls on TF 2301A as follows :

FUNCTION SWITCH at FM DEV+.

METER RANGE at 200 kHz.

Depress both SUPPLY switch and MANUAL switch.

(3) Set the controls on the oscilloscope (h) at 50 mV/cm - Int. trigger - Auto and 20 ms/cm and connect the oscilloscope to SKAD. The waveform displayed should be as Fig. 4.5(a); if a distorted waveform as shown in Fig. 4.5(b) is displayed adjust R52 until the spike just disappears as shown in Fig. 4.5(a).

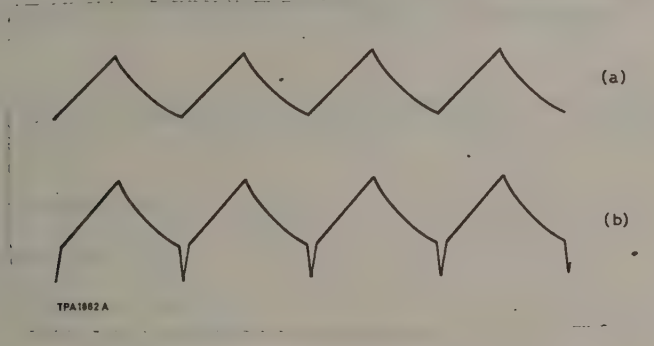


Fig. 4.5 Output waveforms at SKAD

(5) Disconnect the oscilloscope and connect the d.v.m. (m) to SKAD. Set the frequency of the l.f. oscillator (g) at 1 kHz and the output (approximately 75 mV) to obtain a display of 1.500 V on the d.v.m.

4.8 continued

(6) Set the FUNCTION switch alternately at DEV+ and DEV-. The d.v.m. should display 1.500 V for both DEV+ and DEV-. If necessary, adjust R51 on board 3860/15 to obtain the requirement.

(7) With the oscillator (g) output constant, vary the frequency over the range 30 Hz to 200 kHz and verify that the voltage displayed by the d.v.m. is within limits 1.515 and 1.485 V over the frequency range 100 to 200 kHz and is not less than 1.478 kHz at 30 Hz.

(8) Reset the frequency of the oscillator (g) at 1 kHz and check that 1.500 V is displayed on the d.v.m.

(9) Set the METER RANGE switch at 500 kHz and verify that the d.v.m. display is now between the limits 0.472 V and 0.476 V.

(10) Set the FUNCTION switch at AM PEAK and the METER RANGE switch at 30% MOD.

(11) Set the oscillator (g) output (approximately 75 mV) to give a d.v.m. display of 0.316 V.

Set the METER RANGE at 100% MOD.

The d.v.m. display should now be between 0.098 and 0.102 V.

Meter range potentiometer
(Board No. 3860-13)

A signal is applied to the input of the 200 kHz filter 3860-24 to prove the range switching and correct operation of the first and second l.f. amplifiers.

(1) Connect the d.v.m. (m) to output socket SKAD and set the panel controls as follows:

FUNCTION switch at FM DEV+.

DE-EMPHASIS at OFF.

METER RANGE at 500 kHz.

MAX MOD at 200 kHz.

(2) Disconnect the output of the discriminator i.e. PIN 4 on 3860-139 and connect the output of the oscillator (g) in series with a terminated 50 Ω precision attenuator to this lead i.e. the input to the 200 kHz filter.

4.8 continued

(3) Set the attenuator at 0 dB. Set the frequency of the oscillator (g) at 1 kHz and adjust the oscillator output (220 mV) to obtain a display of 474 mV on the d.v.m.

(4) Set the attenuator (n) and the METER RANGE range switch as given in Table 4.5, columns 1 and 2, and verify that the d.v.m. displays are as given in column 3.

Table 4.5

Attenuator setting dB	Meter range switch	d.v.m. display in volts
0	500 kHz	0.474
10	150 kHz	1.500
20	50 kHz	0.974
30	15 kHz	1.500
40	5 kHz	0.474

15 kHz Low-pass filter TM 7702

To reduce noise, the bandwidth is restricted for modulation frequencies below 15 kHz. The test is to prove correct operation of the filter.

With connections and controls set as given in previous section:

(1) Set the attenuator (n) at 0 dB and with the oscillator (g) at a frequency of 1 kHz adjust its output to display 400 mV on the d.v.m.

(2) Set the MAX MOD switch at 15 kHz and check that the d.v.m. display remains at 400 mV.

(3) Maintaining the oscillator (g) output constant, vary the frequency from 30 Hz to 15 kHz and verify that the d.v.m. display remains within the limits 396 to 404 mV.

(4) With the oscillator (g) at 28 kHz and its output as in (1) the d.v.m. display should be between 267 and 300 mV.

De-emphasis
(Board No. 3860-13)

The test is to prove the operation of the ranges of de-emphasis.

(1) With the r.m.s. voltmeter (p) connected to the L.F. OUTPUT terminals TP4-TP5, attenuator (n) set at 0 dB, and the oscillator (g) at a frequency of 100 Hz adjust the oscillator output to set the pointer of the r.m.s. voltmeter at 0 dBm (775 mV).

(2) Set the DE-EMPHASIS switch at 50 μs and verify that the pointer on the r.m.s. voltmeter remains at 0 dBm (775 mV).

4.8 continued

(3) Maintaining the oscillator (g) output constant perform the checks given in Table 4.6 a, b, c, d and then tests e and f.

Table 4.6

Checks	Oscillator frequency	De-emphasis switch at:-	Expected r.m.s. voltmeter reading
a	3.15 kHz	50 μs	-2.5 to 3.5 dB
b	22.5 kHz	50 μs	-15.9 to 17.9 dB
c	2.1 kHz	75 μs	-2.5 to 3.5 dB
d	15 kHz	75 μs	-15.9 to 17.9 dB
e	55 Hz	750 μs and adjust oscillator to set the meter pointer at 0 dBm (775 mV)	
f	210 Hz	750 μs	-2.5 to -3.5 dB
g	1.5 kHz		-15.9 to 17.9 dB

Automatic level control (ALC)
(Board No. 3860-163)

The test, which is intended to prove correct operation of the automatic level control circuit, also includes a check on the operation of the up/down counter, solenoid drivers, attenuator setting and the a.m. detector.

(1) Set the signal generator (b) for an unmodulated r.f. output of 20 mV at 10 MHz and apply this signal to SKAA.

(2) Set the local oscillator at 11.5 MHz and apply this signal to SKAB. Set the function switch to TUNE OSCILLATOR.

(3) Connect a frequency counter to SKAC and verify that the i.f. frequency is exactly 1.5 MHz; if necessary adjust the frequency of the local oscillator to obtain 1.5 MHz.

(4) Connect the r.f. millivoltmeter (e) to the source end of the 10 kΩ i.f. output resistor which is attached to SKAC. and verify that the signal level is 0.5 V.

Note: Measurement of the level at SKAC will cause error due to capacitive loading by the voltmeter.

(5) Increase the r.f. input by dB increments to a maximum of 1 V or up to 5 V if signal source available and check that the voltmeter reading remains at 0.5 V for each increased input.

If the voltmeter reading is not maintained checks should be made to ensure that the up/down counter and associated solenoid driver circuits are operating correctly, that outputs from the mixer and squelch circuits are correct and that the gain control stage, i.f. amplifier, loop amplifier and a.m. detector are operating.

4.8 continued

(6) Reduce the r.f. input to 20 mV. Check that the voltmeter reading is 0.5 V. Position the FUNCTION switch at FM-SET FREQ. The voltmeter reading should fall; proving that the i.f. attenuator has been switched into circuit for f.m. measurements.

Logic board 3860-138

Control inputs and outputs of the logic board are detailed on Drawing No. Z44825-606 and the b.c.d. inputs required for function and range switching are applied through PLBA when TF 2301A is switched to perform programmed tests.

To prove correct operation of the logic board when the instrument is switched for automatic tests, b.c.d. inputs are applied as given in Table 2.1 and checks are then made to ascertain that the required function and range has been selected. Range control is by three wires at input of 3860-138 fanning out to eight lines.

If the selected function or range is not obtained a check using the multimeter (a) on d.c. range 0 - 25 V should be made to prove that the correct logic levels are present e.g. :

For meter range 500 kHz - input pins 34, 27, 33 at logic levels 1-0-1 respectively, output pins 32, 30, 29, 26, 28, 25, 40, 50 at logic levels 1-1-1-1-1-1-1-0 respectively.

If logic outputs are proved correct, check inputs to the relay board and associated relays.

When TF 2301A is switched for MANUAL operation, logic levels are applied to the control inputs of the logic board through the switches on the front panel. Checks for correct operation are as given for programmed tests.

4.8 continued

Relay board 3860-13

Selection of the functions and ranges of TF 2301A is finally dictated by relays operated by outputs from the logic board.

The circuit diagram (Drawing No. Z 44843-607) details the function of each relay and shows input and output connections to the board.

Suspected failure of operation of a particular relay can be verified by disconnecting the related input wire and connecting the associated board connection to 0 V. Check that the relay contacts provide the required switching.

4.9 REMOVING SUB-ASSEMBLIES

Printed circuit boards

The following are plug-in circuit boards which can be removed by lifting a spring clip and pulling the board upwards.

(1) 1st L. F. Amplifier

(2) 2nd L. F. Amplifier

(3) Peak Detector

(4) A. L. C. Board

(5) Calibrator

(6) Attenuator Control

The relay and logic control boards located on the underside of the chassis are hinged to allow access to the squelch board and edge connectors related to the l. f. amplifiers and peak detector. Discriminator and limiter boards are contained in a screened compartment on the underside of the chassis and are accessible when the cover is removed.

The i. f. amplifier unit can be removed when necessary by unsoldering one lead and disconnecting two miniature plugs. Three screws retain the unit to the chassis. Access for adjustment is provided by a removable cover, to enable the inductors of the tuned circuits to be adjusted through holes in the back of the circuit boards with a trimmer tool.

The printed circuit boards 3860-014 and 3860-161 in the power unit can be removed when the metal top plate is removed.

4.9 continued

200 kHz and 15 kHz low-pass filters

Either of these units can be removed by unsoldering two connections and releasing two screws. The 200 kHz filter is adjustable through holes in the chassis.

4.10 REPLACING TRANSISTORS

Transistors that are mounted in holders may need to be selected for low noise if replaced.

4.11 CLEANING AND LUBRICATION

Rotary switch contacts

These should be cleaned once or twice a year, depending on usage, with benzine or white spirit (not carbon tetrachloride). After cleaning wipe the contacts with a suitable lubricant such as a 1% solution of petroleum jelly in white spirit.

4.12 ORDERING NEW CIRCUIT BOARDS

All printed circuit boards in this instrument have a reference number marked on them.

When ordering replacement boards, do not use the reference number on the board; it is essential that only the title of the board and the Marconi Instruments code number is quoted to ensure that you are sent the correct board for your instrument.

Table 4.7 lists the title and reference number (or numbers) for every board, together with the appropriate ordering code number.

Table 4.7

Board title	Reference number	Ordering code
Attenuator control	3860/11	44846-222
Automatic level control	3860/163	44826-626
Relay control	3860/13	44843-607
+5 V, +12 V, +18 V supplies	3860/14	44824-644
Peak reading voltmeter	3860/15	44824-645
2nd l.f. amplifier	3860/21	44824-405
Limiter	3860/22	44823-279
I.F. amplifier	3860/23	44823-280
Discriminator	3860/137	44823-282
Logic control	3860/138	44825-606
1st l.f. amplifier	3860/159	44822-133
Calibrator	3860/160	44824-406
-18 V and -12 V supply	3860/161	44822-134
Squelch circuit	3860/10	44823-277

4.13 REPAIR

If information is required please write or telephone Marconi Instruments Ltd., Service Division - see address on back cover - or contact nearest representative quoting the type and serial number on the data plate at the rear of the instrument.

If the instrument is being returned for repair please indicate clearly the nature of the fault or the work you require to be done.

4.14 PRINTED CIRCUIT BOARD LAYOUTS

Figs. 4.6 to 4.15 show the positioning of components on the various printed circuit boards.

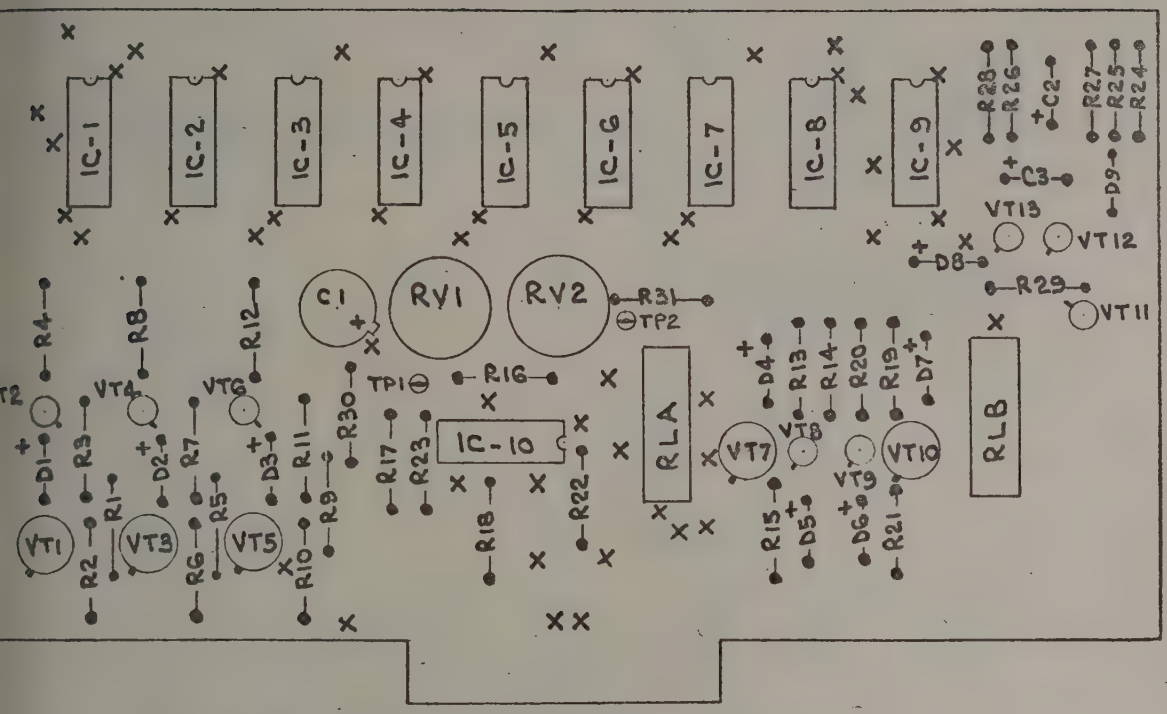
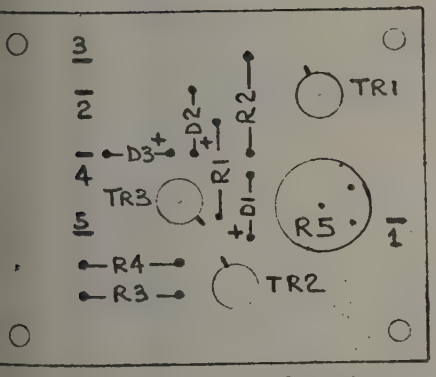


Fig. 4.6 : Attenuator control board, 44846-222



g. 4.7 : Squelch circuit, 44823-277

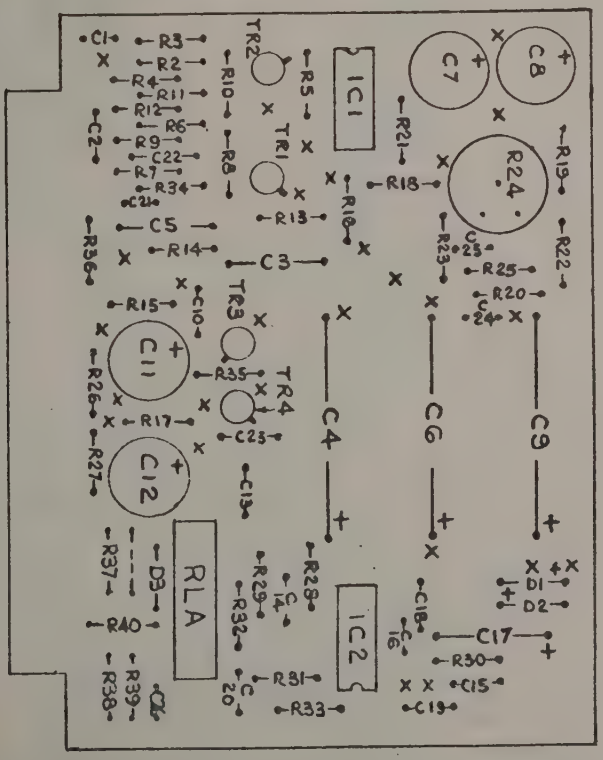
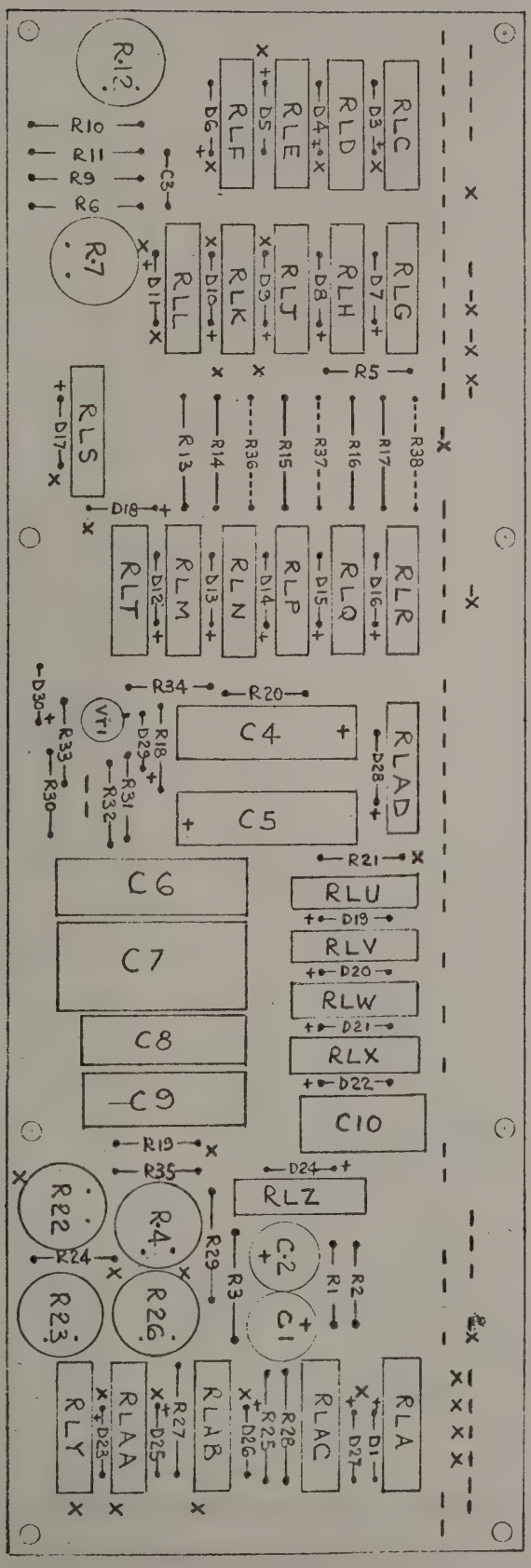
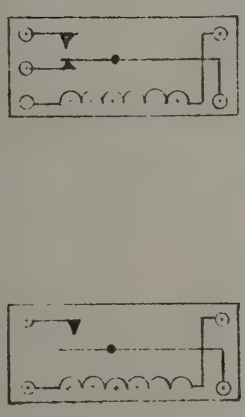


Fig. 4.8 : Automatic level control board, 44826-626

ig. 4.9 : Relay control board, 44843-607





MEPI-IMC/G3 MEPI-IMA/G3

VIEW ON UNDERSIDE OF RELAY

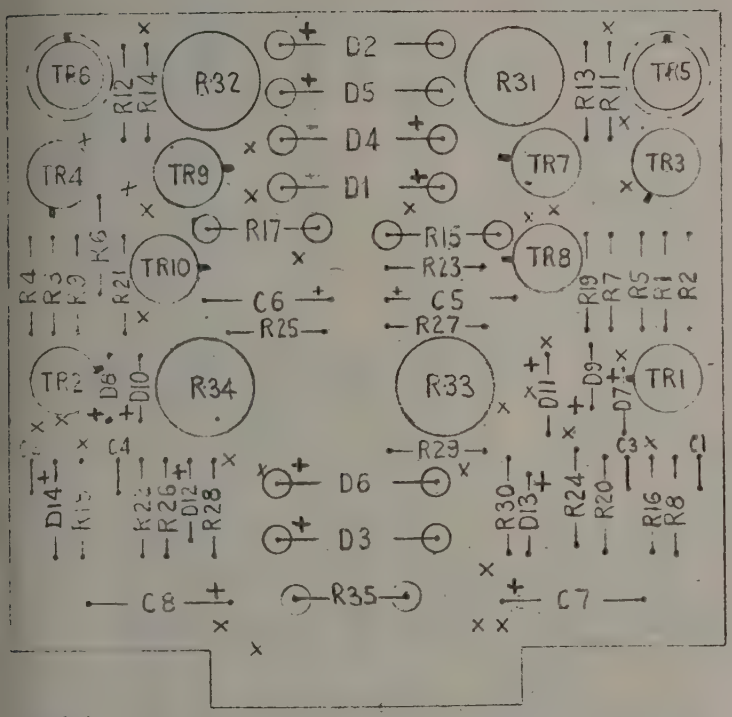


Fig. 4.10 : +5 V, +12 V, +18 V supplies, 44824-644

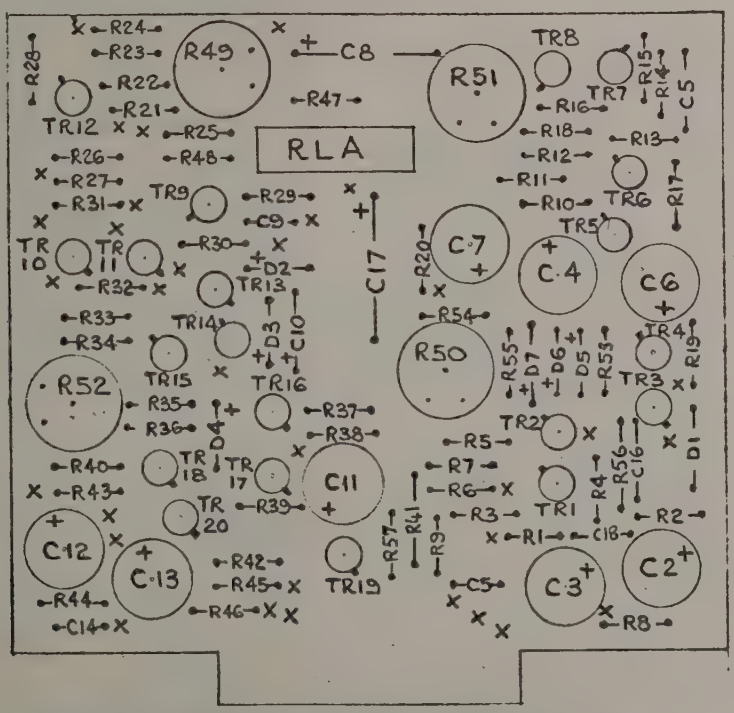


Fig. 4.11 : Peak reading voltmeter board, 44824-645

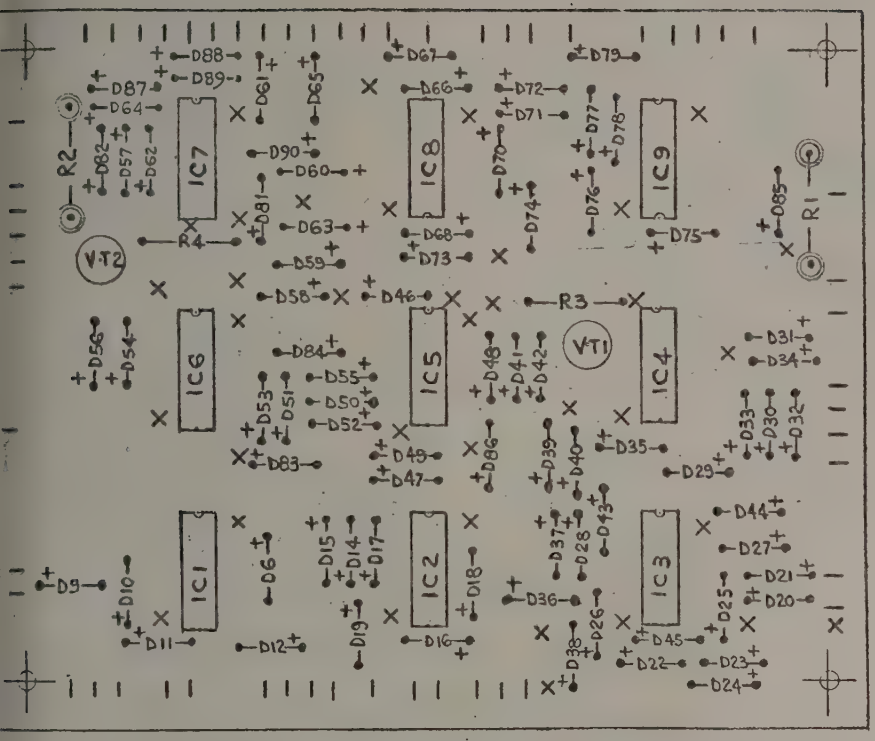


Fig. 4.12 : Control logic board, 44825-606

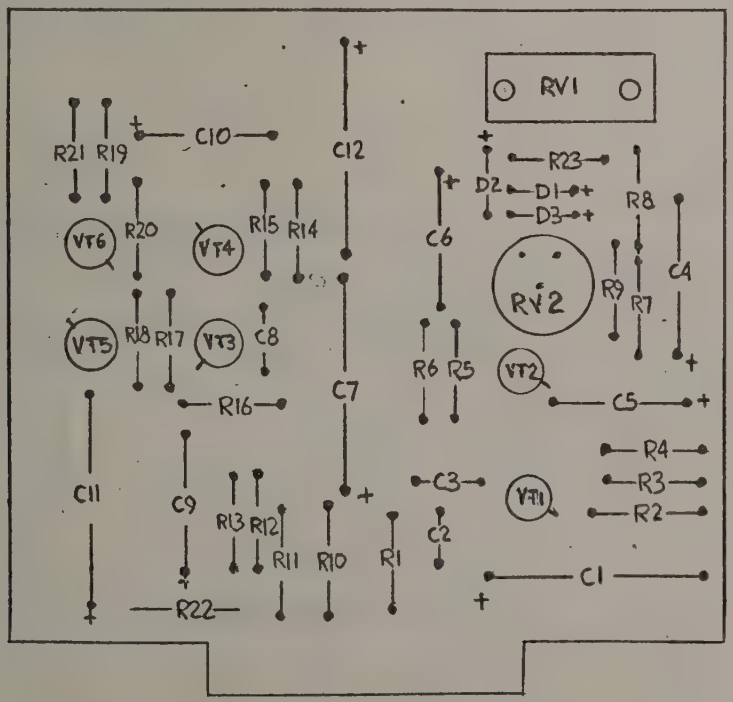


Fig. 4.13 : 2nd l.f. amplifier, 44824-405

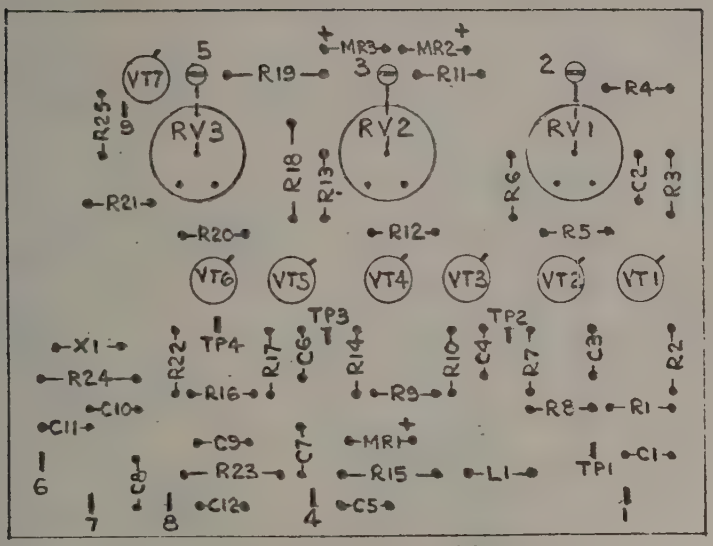


Fig. 4.14 : Limiter board, 44823-279

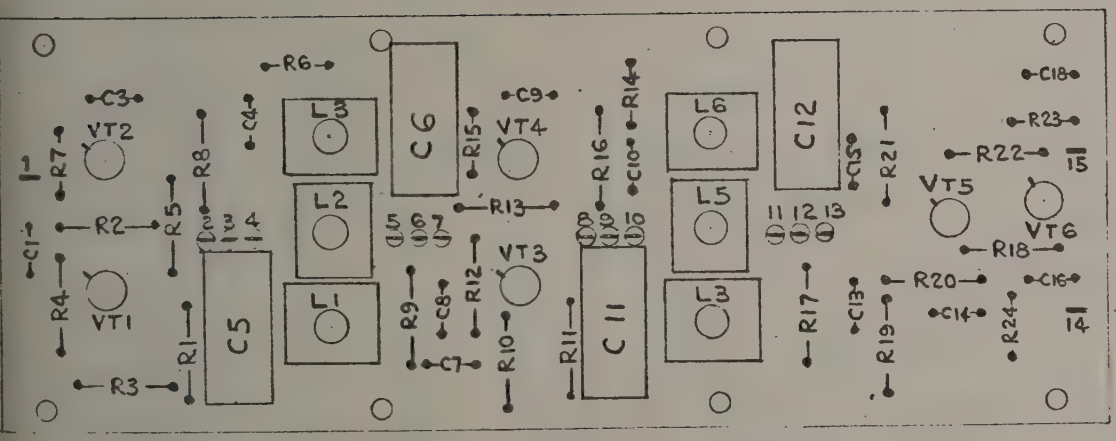
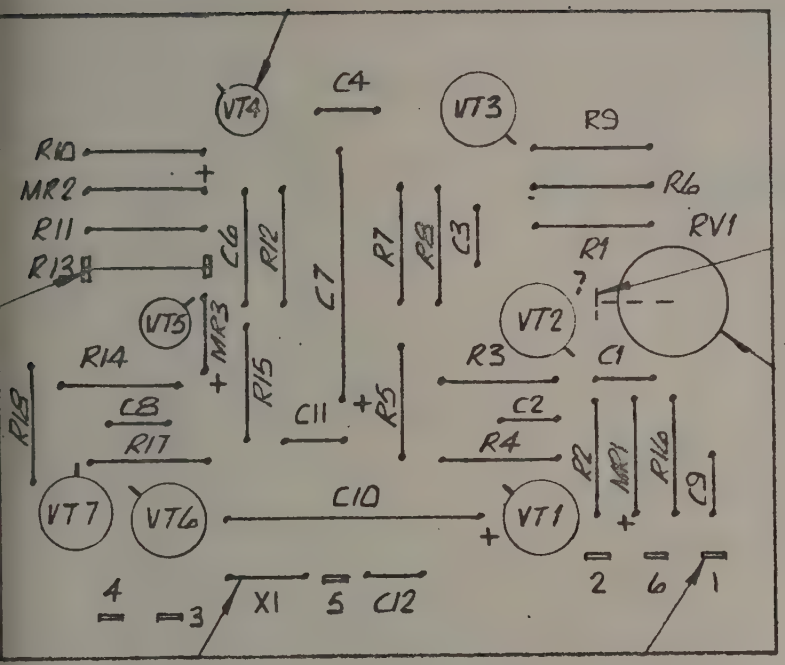
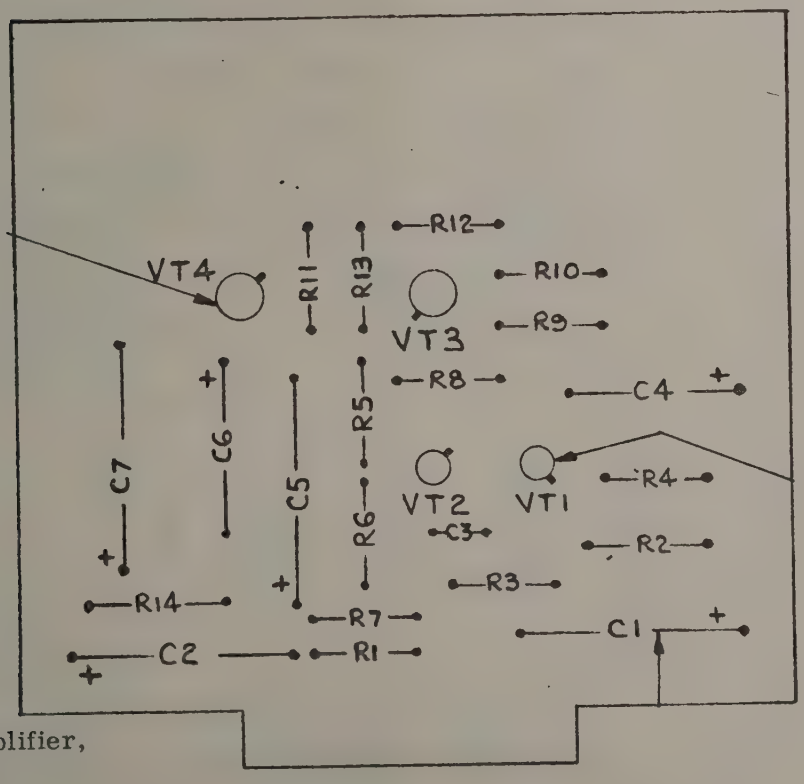


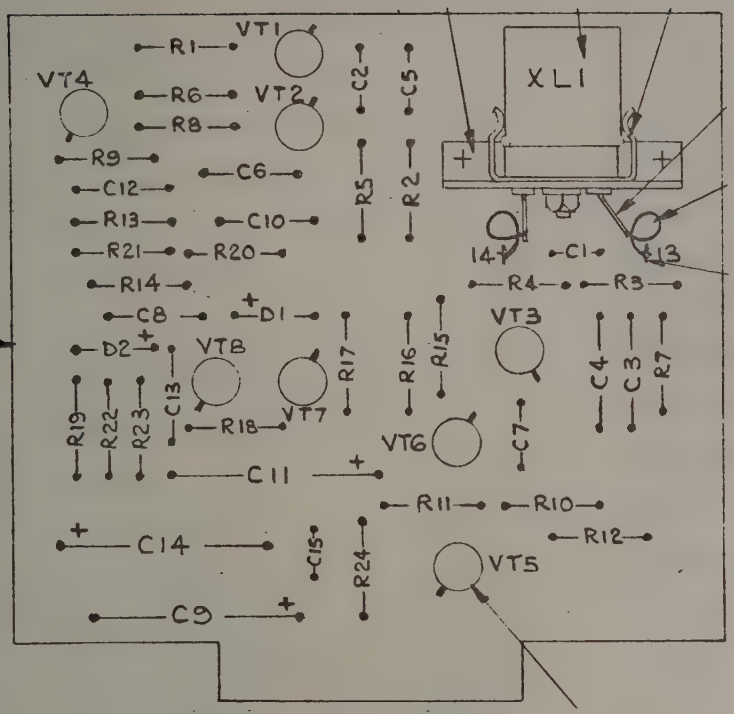
Fig. 4.15 : I. F. amplifier board, 44823-280



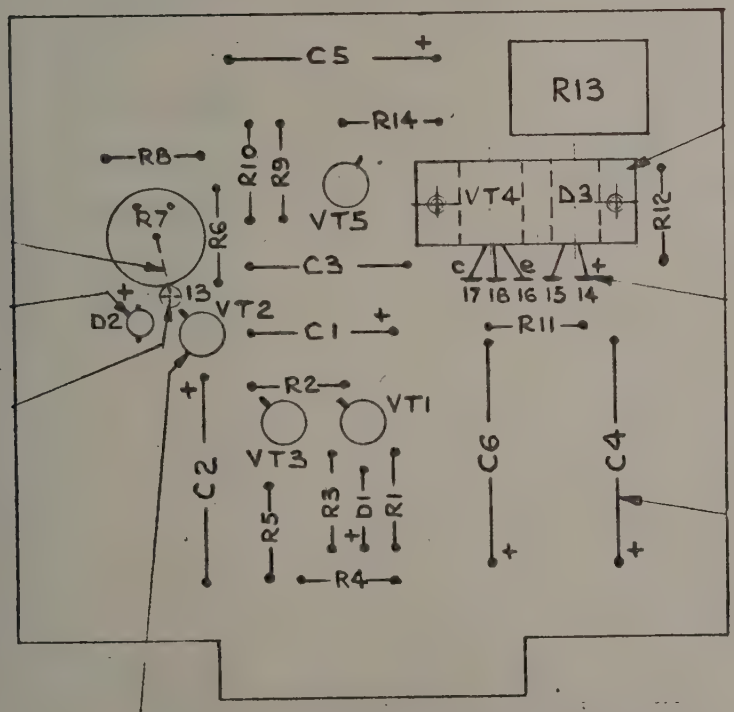
4.16 : Discriminator, 44823-282



4.17 : 1st l.f. amplifier, 44822-133



4.18 : Calibrator, 44824-406



4.19 : -18 V and -12 V supply, 44822-134

CIRCUIT DIAGRAMS

Block schematic diagram	Y 46465-004, sheet 1
Control functional diagram	Y 46465-004, sheet 2
Interconnecting diagram :	Z 46465-004
Attenuator control :	Z44846-222
Automatic level control :	Z 44826-626
Relay control :	Z44843-607
+5 V, +12 V, +18 V supplies :	Z44824-644
Peak reading voltmeter :	Z44824-645
2nd l. f. amplifier :	Z44824-405
Limiter :	Z44823-279
I. F. amplifier :	Z44823-280
Discriminator :	Z44823-282
Logic control :	Z 44825-606
1st l. f. amplifier :	Z44822-133
Calibrator :	Z44824-406
-18 V and -12 V supply :	Z44822-134
Squelch circuit :	Z44823-277
Attenuator :	Z44425-516
Mixer :	C44412-030
150 kHz filter :	Z44414-137
50 kHz filter :	B44414-136
15 kHz filter :	XC 42795

DECIBEL CONVERSION TABLE

Ratio Down			Ratio Up	
VOLTAGE	POWER	DECIBELS	VOLTAGE	POWER
1·0	1·0	0	1·0	1·0
·9886	·9772	·1	1·012	1·023
·9772	·9550	·2	1·023	1·047
·9661	·9333	·3	1·035	1·072
·9550	·9120	·4	1·047	1·096
·9441	·8913	·5	1·059	1·122
·9333	·8710	·6	1·072	1·148
·9226	·8511	·7	1·084	1·175
·9120	·8318	·8	1·096	1·202
·9016	·8128	·9	1·109	1·230
·8913	·7943	1·0	1·122	1·259
·8710	·7586	1·2	1·148	1·318
·8511	·7244	1·4	1·175	1·380
·8318	·6918	1·6	1·202	1·445
·8128	·6607	1·8	1·230	1·514
·7943	·6310	2·0	1·259	1·585
·7762	·6026	2·2	1·288	1·660
·7586	·5754	2·4	1·318	1·738
·7413	·5495	2·6	1·349	1·820
·7244	·5248	2·8	1·380	1·905
·7079	·5012	3·0	1·413	1·995
·6683	·4467	3·5	1·496	2·239
·6310	·3981	4·0	1·585	2·512
·5957	·3548	4·5	1·679	2·818
·5623	·3162	5·0	1·778	3·162
·5309	·2818	5·5	1·884	3·548
·5012	·2512	6	1·995	3·981
·4467	·1995	7	2·239	5·012
·3981	·1585	8	2·512	6·310
·3548	·1259	9	2·818	7·943
·3162	·1000	10	3·162	10·000
·2818	·07943	11	3·548	12·59
·2512	·06310	12	3·981	15·85
·2239	·05012	13	4·467	19·95
·1995	·03981	14	5·012	25·12
·1778	·03162	15	5·623	31·62

DECIBEL CONVERSION TABLE

Ratio Down			*Ratio Up*	
VOLTAGE	*POWER*	*DECIBELS*	*VOLTAGE*	*POWER*
·1585	·02512	16	6·310	39·81
·1413	·01995	17	7·079	50·12
·1259	·01585	18	7·943	63·10
·1122	·01259	19	8·913	79·43
·1000	·01000	20	10·000	100·00
·07943	·006310	22	12·59	158·5
·06310	·003981	24	15·85	251·2
·05012	·002512	26	19·95	398·1
·03981	·001585	28	25·12	631·0
·03162	·001000	30	31·62	1,000
·02512	·0006310	32	39·81	1,585
·01995	·0003981	34	50·12	2,512
·01585	·0002512	36	63·10	3,981
·01259	·0001585	38	79·43	6,310
·01000	·0001000	40	100·00	10,000
·007943	·00006310	42	125·9	15,850
·006310	·00003981	44	158·5	25,120
·005012	·00002512	46	199·5	39,810
·003981	·00001585	48	251·2	63,100
·003162	·00001000	50	316·2	100,000
·002512	$6{\cdot}310 \times 10^{-6}$	52	398·1	158,500
·001995	$3{\cdot}981 \times 10^{-6}$	54	501·2	251,200
·001585	$2{\cdot}512 \times 10^{-6}$	56	631·0	398,100
·001259	$1{\cdot}585 \times 10^{-6}$	58	794·3	631,000
·001000	10^{-6}	60	1,000	10^{6}
·0005623	$3{\cdot}162 \times 10^{-7}$	65	1,778	$3{\cdot}162 \times 10^{6}$
·0003162	10^{-7}	70	3,162	10^{7}
·0001778	$3{\cdot}162 \times 10^{-8}$	75	5,623	$3{\cdot}162 \times 10^{7}$
·0001000	10^{-8}	80	10,000	10^{8}
·00005623	$3{\cdot}162 \times 10^{-9}$	85	17,780	$3{\cdot}162 \times 10^{8}$
·00003162	10^{-9}	90	31,620	10^{9}
·00001000	10^{-10}	100	100,000	10^{10}
$3{\cdot}162 \times 10^{-6}$	10^{-11}	110	316,200	10^{11}
10^{-6}	10^{-12}	120	10^{6}	10^{12}
$3{\cdot}162 \times 10^{-7}$	10^{-13}	130	$3{\cdot}162 \times 10^{6}$	10^{13}
10^{-7}	10^{-14}	140	10^{7}	10^{14}

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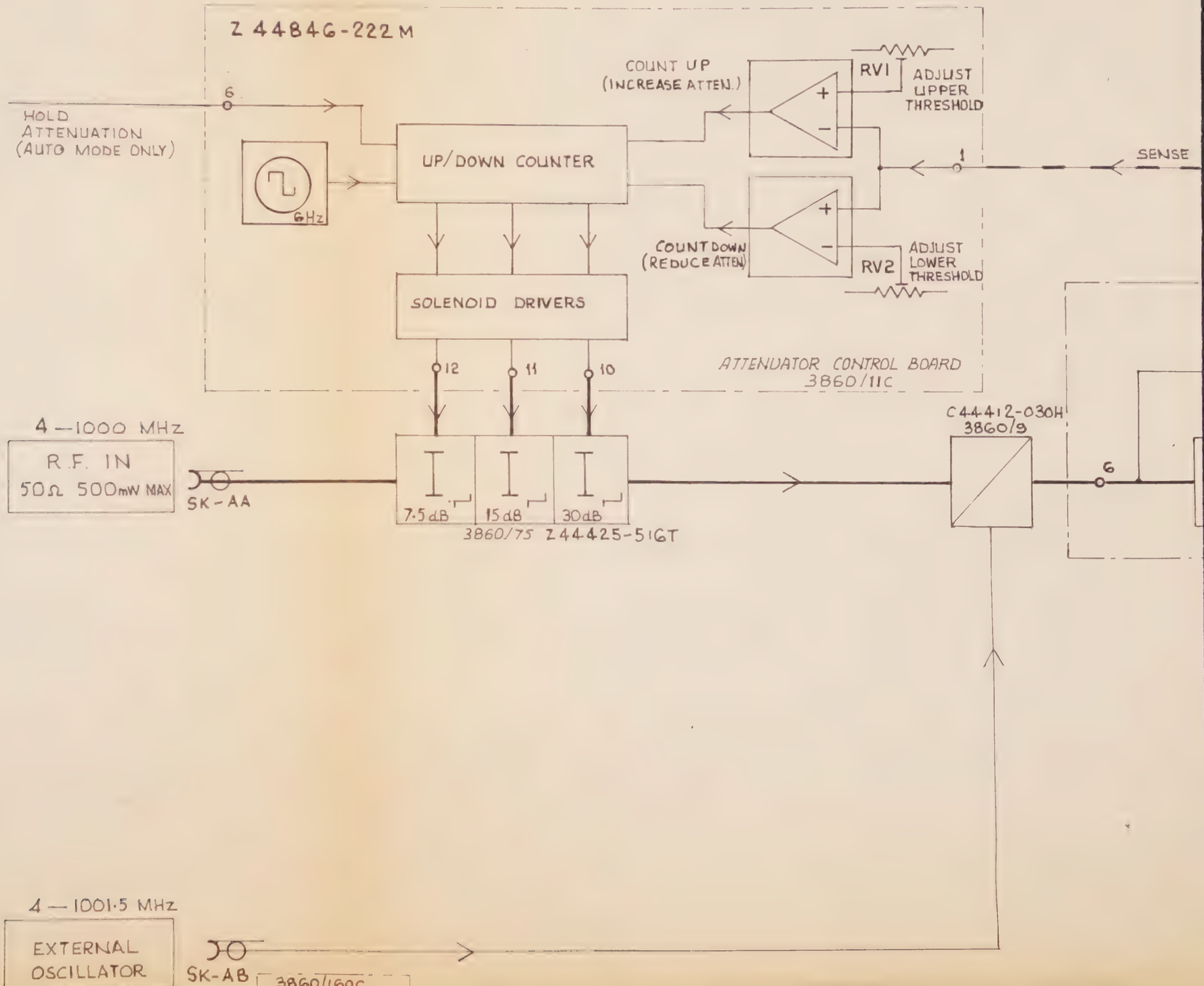


NY

NOTES

1. SWITCH FUNCTIONS ARE NOT FULLY DETAILED. THEY LABEL THE SIGNAL PATHS FOR A.M. AND F.M. MEASUREMENTS BUT NOT THE 'TUNE' AND SET FREQUENCY FUNCTIONS.

FIRST USED

ISS	CHANGES
2	AEH. OSCILLATOR DELETED. REVISED AND CORRECTED 23-7-71
3	AT237 Z44824-406Y WAS -405H 23-6-72

R F LEVEL

Z 44826-626S

AUTOMATIC LEVEL CONTROL BOARD
3860/163C

SET I.F LEVEL

R24

LOOP AMPLIFIER

DC ∝ I.F LEVEL

RIG

CONTROL LOOP

C6

LOOP STABILIZING TIME CONSTANT

IF OUTPUT 10KΩ

19

R12 10K SK-AC

Z 44823-280E

ADJUST RESPONSE

ADJUST RESPONSE

L1 L2 L3

1.5MHz

L4 L5 L6

1.5MHz

I F AMPLIFIER BOARD — 3860/23C

AM

FM

RLA

28 dB

GAIN

1

2

8

14

24

AM DETECTOR

16

12

SENSE I.F. LEVEL

3860/100

4

SQUELCH

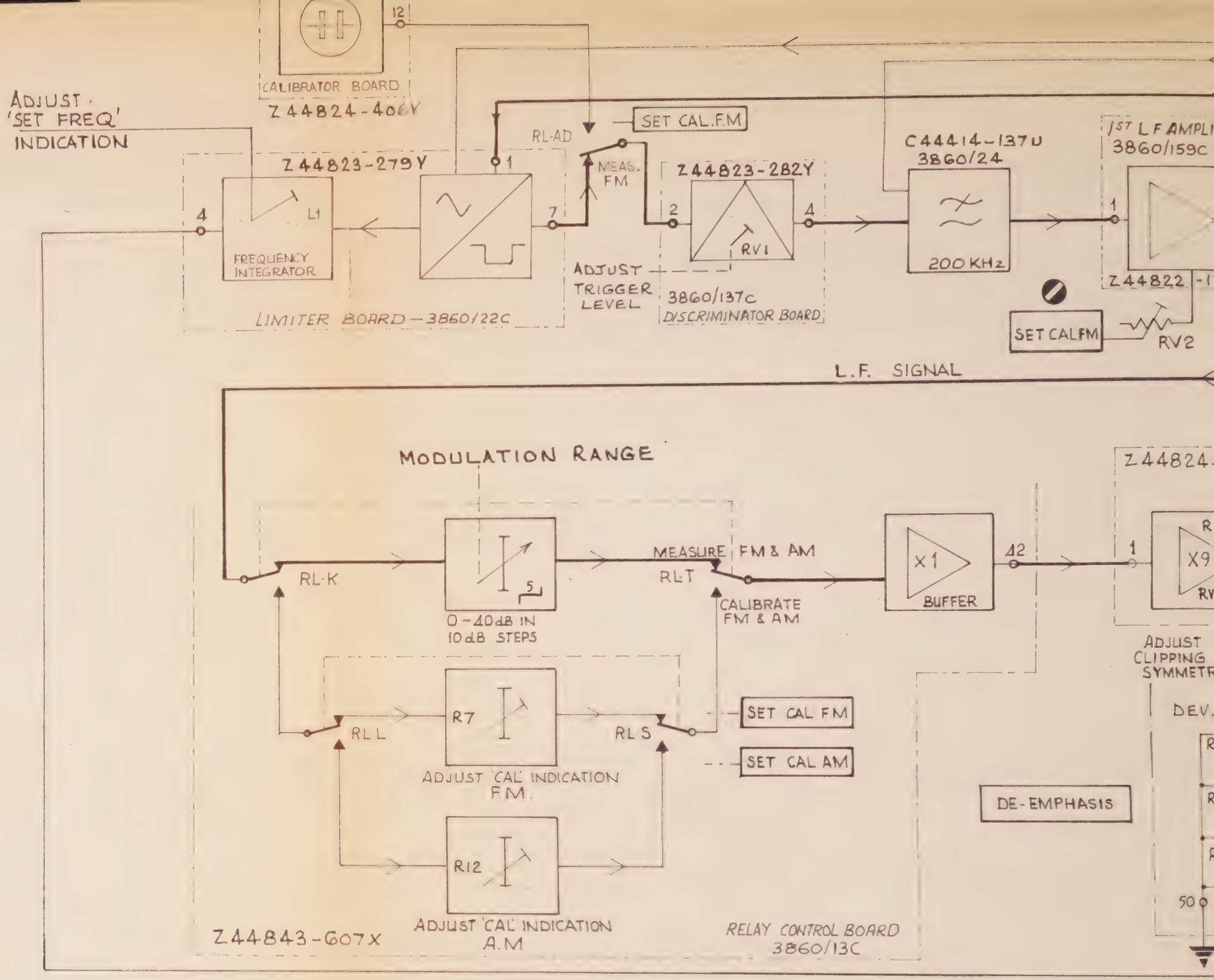
Z 44823-277E

R5

ADJUST DC BIAS

2

1



CHECKED / /	DIMENSIONS IN INCHES M.M.	MATERIA
		M.I. LTD SPEC.
TRACED / /	SCALE	
DRAWN 1/12/70 J. L-M. D. J. Williams	APPROVED / /	

D.C. BIAS

I.F. SIGNAL (IN FM MODE)

200 KHz

RL-G

XC 42795

RL-H

TM7702

15 KHz

15 KHz

MAX. MOD FREQ.

FM

AM

L.F. SIGNAL (IN FM MODE)

RL-J

B 44414-136E

50 KHz 3860/4

RG

SET CAL. AM

LF SIGNAL (IN AM MODE)

6

ADJUST METER ZERO

R22

R23, ADJUST TUNE INDICATION

RELAY CONTROL BOARD 3860/13C

Z 44843-607X

405U 2ND L.F. AMPLIFIER BOARD – 3860/21C

ADJUST AF GAIN

R10

R11

× 20

600Ω 12

R22

L.F. OUTPUT

LF OUTPUT 600Ω

TP4

7

9

61

R4

30% & 100% A.M. 5 – 500KHz DEVIATION RANGES

SET FS D. 1·5KHz DEV. RANGE

1·5 KHz DEV. RANGE

RL-A

2

ADJUST DETECTOR DISCHARGE THRESHOLD

SET OUTPUT ZERO

RANGES 5, 50, 500 KHz, & 100% A.M.

SK-AD

OUTPUT

RL-AC

× ⅓

10dB

RL AB

AM

FM

RANGES 1·5, 15, 150 KHz & 30% A.M.

READ METER ON AUTO

RANGES 5-500 KHz

1·5 KHz

C10

55

C6

50 μS

C7

75 μS

C8, C9

750 μS

Z 44824-645Y

ADJUST L.F. GAIN

TROUGH A.M. -VE DEV

SET UNITY GAIN

5

× 13

R50

RL-A

PEAK A.M. +VE DEV.

−1

R51

R49

R52

PEAK DETECTOR

8

59

R26

ADJUST METER SENSITIVITY

RL AA

AUTO

MAN

V

RL-Z

RL-Y

SET FREQUENCY

TUNE

Z 44843-607X

RELAY CONTROL BOARD 3860/13C

PEAK READING VOLTMETER BOARD – 3860/15C

DC ∝ IF

	FINISH	TOLERANCES UNLESS OTHERWISE STATED	TITLE	DRAWING NUMBER SH. 1 OF 2 SHTS
	M.I. LTD SPEC.	0.0 ± 0.5 mm (± ·020) 0.00 ± 0.2 mm (± ·008) METRIC TOLERANCES APPLY INCH EQUIVALENTS IN BRKTS.	BLOCK SCHEMATIC DIAGRAM TF2301A	Y 4 6 4 6 5 – 0 0 4 P
			MARCONI INSTRUMENTS LIMITED ST. ALBANS ENGLAND	PRELIM. DWG. No MY3860·100 · THIRD ANGLE PROJECTION · ISO A 1

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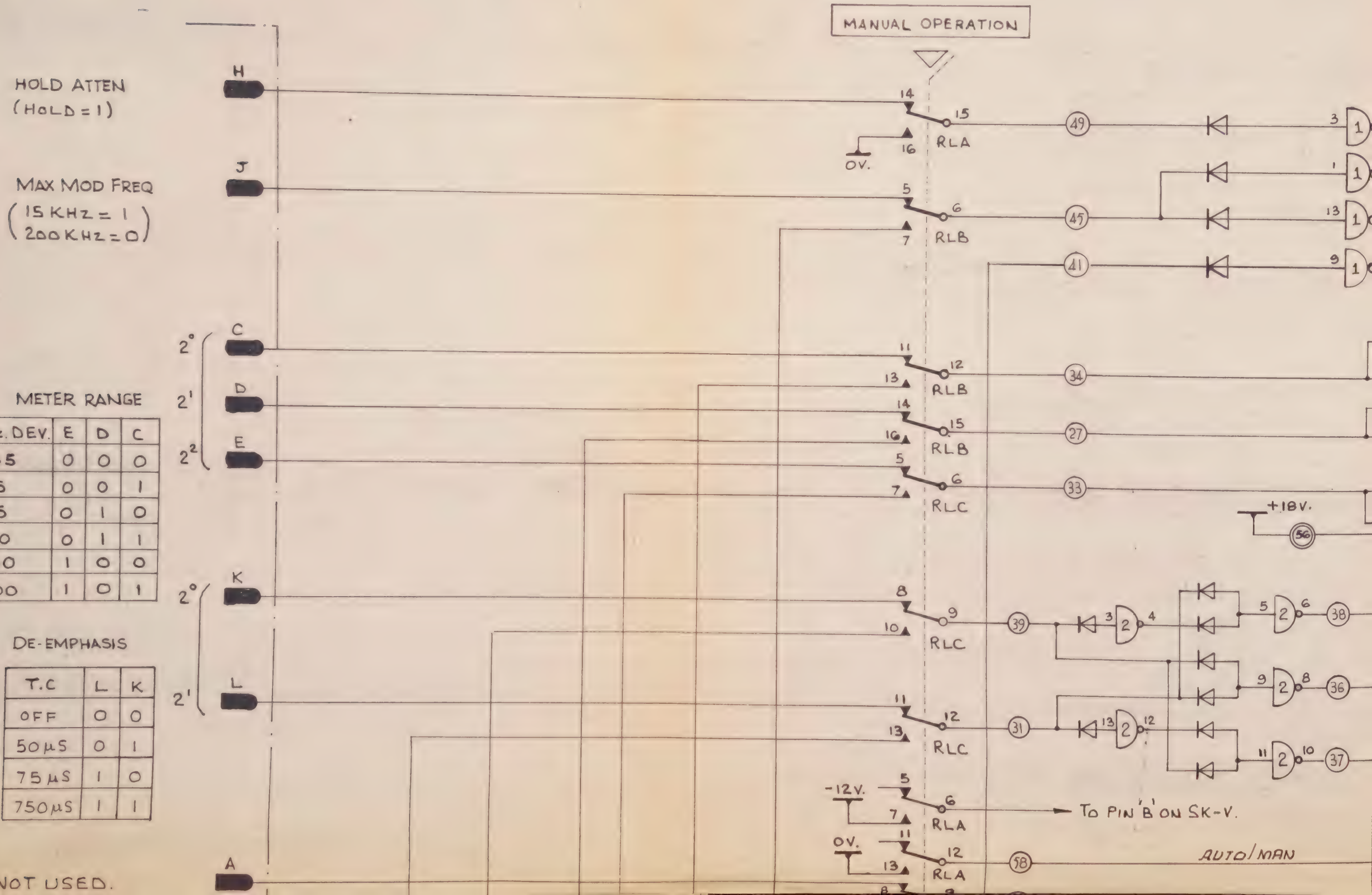


METER RANGE

KHz. DEV.	E	D	C
1·5	0	0	0
5	0	0	1
15	0	1	0
50	0	1	1
150	1	0	0
500	1	0	1

DE-EMPHASIS

T.C	L	K
OFF	0	0
50μS	0	1
75μS	1	0
750μS	1	1

HE COMPANY

NOTES

FIRST USED
TF 2301A

ISS	CHANGES

+18V.

μSec
OFF 50 75 750
SC

30 100 % A.M.
1·5 5 15 50 150 500 KHz DEV.
SB

AM TUNE FM
SET FREQ — SET FREQ
PEAK — DEV +
TROUGH — DEV −
SET CAL — SET CAL
Ext. Std. 50% A.M.
Int. Std.
SA

RL-C
RL-G
RL-H
RL-AB
RL-X
RL-A
RL-M
RL-N
RL-P
RL-Q
RL-R
RL-AC
RL-V
RL-W
RL-U

46 20
47 16
42 31
43 3
23
52
53
51
54
62
41
40
39
38
37
63
32
30
29
26
28
25
40
50
56

'B' 'A'

± DEV & PEAK/TROUGH (DEV. TROUGH = 1)
AM/FM (A.M. = 1)
NORMALLY NOT USED (SEE HANDBOOK)

F
B
M

PL-BA

RLF-1 3860/13.

RL-F

SB2R
SB1R
SCR
SA1R
SA2R
SA3R

RLA
RLC
SE
RLB
SD
RL-E

+18V.
0V.
200KHz
15KHz

TO PIN 'D' ON SK-V

TAGS ON LOGIC CONTROL
TAGS ON RELAY CONTROL
MISCELLANEOUS TAGS

CHECKED / /	DIMENSIONS IN INCHES M.M.	M.I. LTD SPEC.
TRACED / /	SCALE	
DRAWN 8/12/70 J.L.M. DJW.	APPROVED / /	

+18V. PIN 'F' ON SK-V

+18V. STANDOFF INSULATOR ON CHASSIS

OV

+18V. PIN 'J' ON SK-V

+18V. PIN 'H' ON SK-V

+18V.

OV.

STANDOFF INSULATOR ON CHASSIS.

'A'

'B'

RL-A

3860/15 Z44824-645Y

+18V.

RL-A

3860/163 Z44826-626S

+18V.

RL-L

RL-S

RL-AD

RL-D

RL-K

RL-T

RL-Y

RL-Z

RL-AA

P.C.B. 3860/138 SEE Z44825-606V

P.C.B. 3860/13 SEE Z44843-607X

R CONNECTIONS.

SH

READ METER

OV.

MATERIAL	FINISH	TOLERANCES UNLESS OTHERWISE STATED	TITLE	DRAWING NUMBER SH. 2 OF 2 SHTS
	M.I. LTD SPEC.	0.0 ± 0.5 mm (± ·020) 0.00 ± 0.2 mm (± ·008) METRIC TOLERANCES APPLY INCH EQUIVALENTS IN BRKTS.	CONTROL FUNCTIONAL DIAGRAM - TF2301A.	Y46465-004P

MARCONI INSTRUMENTS LIMITED
ST. ALBANS ENGLAND

PRELIM. DWG. No MY3860-100

THIRD ANGLE PROJECTION

ISO A 1

PL-D

SK-D

ATTENUATOR
(ME 3860/75)
Z 44425-51GT
7·5dB | 15dB | 30dB
1 2 3 4 5 6

SK-CG
(ATTENUATOR CONTROL)
(M3860/11
Z 44846-222M
6 2 4 3 7 8 9
+12V 0V +5V
−12V +18V

SEE NOTE 4

PL-BA

RANGE A — A
HOLD ATTEN. — H
MAX. MOD — J
* F.M. SENSITIVITY — M
METER RANGE 2° — C
METER RANGE 2¹ — D
METER RANGE 2² — E
DE-EMPHASIS 2⁰ — K
DE-EMPHASIS 2¹ — L
± DEV & PEAK/TRIGGER AM/FM — F
N — +5V
P — +18V
R — 0V
B

* WIRING TO PIN M SEE NOTE 5

SK-W

RL-A

1 5 7 8 10 11 13 14 16
−12V
0V
4 6 9 12 15
+18V

SK-X

RL-B

1 5 7 8 10 11 13 14 16
4 6 9 12 15
+18V

SEE NOTE 5
0V

RL-C

1 5 7 8 10 11 13 14 16
4 6 9 12 15
+18V

52 58 49 45 2 34 27 33 39 31 10

24 62 35 57 59 4 46 22 9 41 47 42 6 21 15 29 26 28 25 40

CONTROL Z44825-606V (M3860/138)

(M3860/13)

20 22 25 16 31 15 14 13 41 40 39 38 37

18 24 19 23 32 6 26 56 11 47 44

CONTROL Z44843-607X

+18V

SKV

SBIR

0V 12 2 10 9

METER RANGE
30 100 ——— %AM
1·5 5 15 50 150 500KHz DEV

4 8 7 LIMITER (MC 3860/22) 6

1. When OSCILLATOR & COAX switches are not fitted PLUG PL-K into SK-F & PL-S into SK-E

2. ~~6a~~ Use RG58C/u (15650-325)
   ~~6b~~ – HF cable. Coax (15650-455)
   ~~(-)~~ – Min. Coax (15680-321)
   ALL OTHER WIRING IN 7/0076.

3. POWER SUPPLY: USE 14/0076 except where marked
   ~~6c~~ USE 23/0076

4. 0V. LINE TO BE WIRED TO POWER SUPPLY DIRECT. Z 44846-222M TAG 7.

5. OPTIONAL CONNECTION
   Z 44825-606V TAG 2 IS NORMALLY WIRED TO 0V THIS LINK IS REMOVED WHEN PROGRAMMING OF F.M. SENSITIVITY IS REQUIRED.

ISS	CHANGES
2	AEH PIN REFS PL-E MODIFIED R7 WAS 820Ω R12 ADDED. IF GND FROM LOGIC CONTROL TO SK-AA, SK-AB & SK-CF ADDED NOTE 4 AND 5 ADDED. OSCILLATOR COAX. RELAYS 'B' & 'C' DELETED NOTE 1 DELETED C14 ADDED. 8-7-72
3	AT 217 B 44414-136E WAS 'C' MD 3860/14 WAS 'TM' ON SK-CE, LINK FROM PIN N TO C10 DELETED. C15+16 ADDED. C12 WAS C13. C13 WAS C12. TR2 WAS TR3 TR3 WAS TR2 V.P.B 11-1-72

SK-AA — R.F. IN 50Ω 500mW max
SK-AB — EXT. OSC
SK-AC — I.F OUT 10KΩ
R12 10K
+18V
-12V
PL-C
PL-S
PL-G
SK-E
SK-G
SK-F
PL-K
MIXER (MC3860/9) C44412-030H
SK-CF Z44826 (M3860/13)-626S
AUTOMATIC LEVEL CONTROL
PL-TA
PL-TB
SK-TA
SK-TB
IF AMP (MC3860/23) Z44823-280E
(MD3860/2)
D46713-003X
SET CAL AM
R6 1K
R5 330
R7 1K
50KHz LP MC3860/4 B44414-136E
SET CAL FM
R3 100K
R4 50K
DISC MC3860/37C
200KHz LP MC3860/24
LF AMP (1st)
15KHz LP
SQUELCH
-18V
TP 2
0V
CONTROL COMMON (0V)
C14 0·1
TP 1

SB

DE-EMPHASIS
μ SEC
50 75
OFF 750

SC

AM TUNE OSCILLATOR FM
SET FREQ 2 ① 2 SET FREQ
PEAK 3 3 DEV+
TROUGH 4 4 DEV−
SETCAL 5 5 SET CAL

SA

Max. Mod. Frequency
(FM only)
15
150 KHz

SD

SB2R

SCR

SA 1R

SA 2R

SA 3R

SE

MANUAL OPERATION

LP1

MANUAL INDICATOR

+18V

0V

SD

15 KHz 0 KHz

0V

LP2

SUPPLY

SK-Y

LOGIC

RELAY

D46878
-015D

(MD 38

0V

− 12v

+ 12v

M1

SKCB Z44824
(L F AMP 2ND MC3860/21) 405U

R1 220K

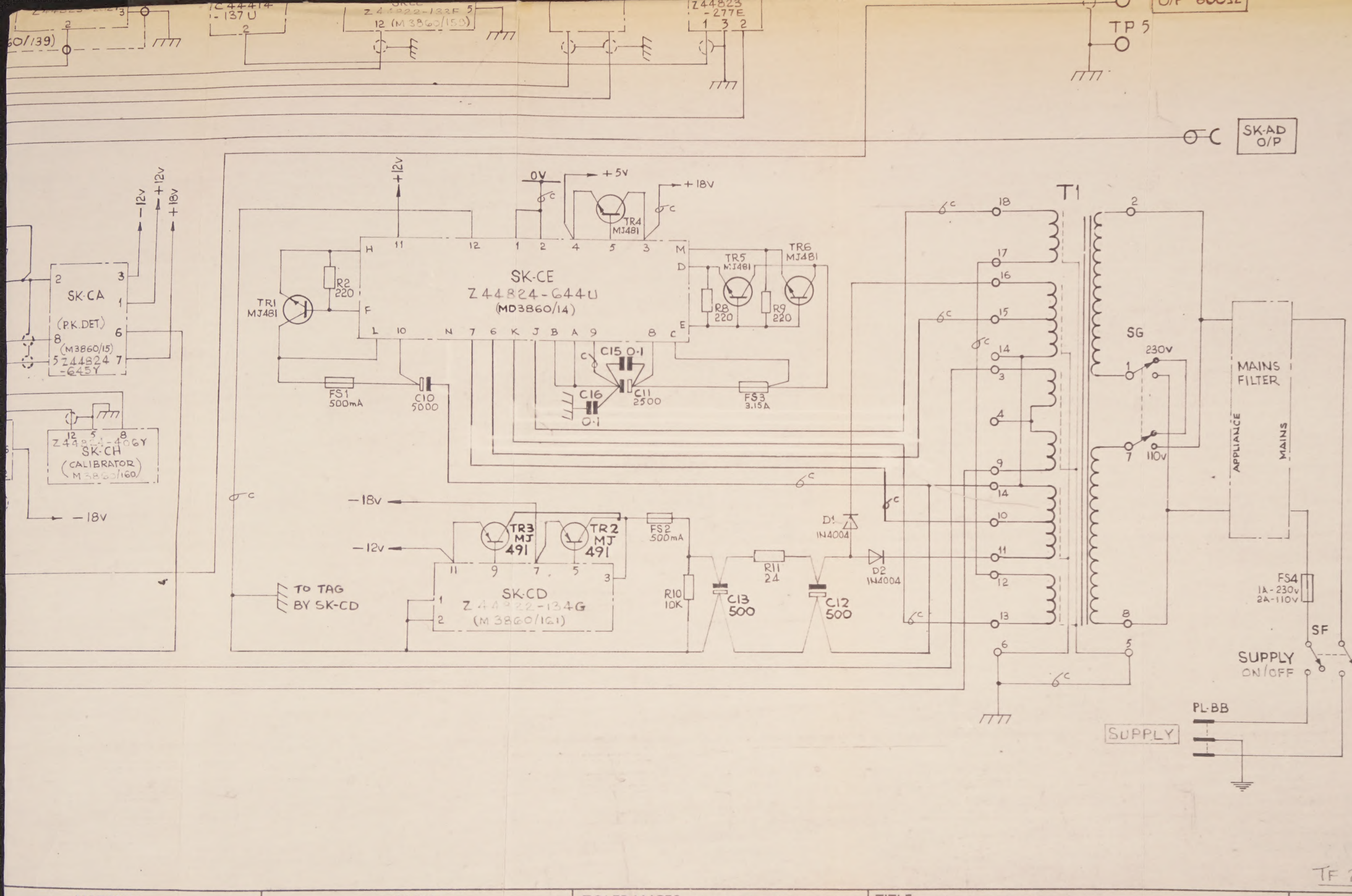
C9 500p

SH

0V

READ METER

CHECKED / /	DIMENSIONS IN INCHES M.M.	M
TRACED / /	SCALE	
DRAWN / / W.E	APPROVED / /	



TF 2301A

MATERIAL	FINISH	TOLERANCES UNLESS OTHERWISE STATED	TITLE WIRING DIAGRAM PROGRAMMABLE FM/AM MODULATION METER	DRAWING NUMBER SH. 1 OF 1 SHTS. Z46465-004P
TD. SPEC.	M.I. LTD. SPEC.		MARCONI INSTRUMENTS LIMITED ST. ALBANS ENGLAND	PRELIM. DWG. No. M3860/150 THIRD ANGLE PROJECTION

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